THREATENED, ENDANGERED, AND NONGAME BIRD AND MAMMAL INVESTIGATIONS

Wyoming Game and Fish Department Nongame Program
Statewide Wildlife and Habitat Management Section
Wildlife Division

Annual Completion Report

Period Covered:
15 April 2015 to 14 April 2016

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United States Fish and Wildlife Service Section 6 Funding (USFWS S6)
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Wyoming Governor's Endangered Species Account Fund (WGESAF)
Wyoming State Legislature General Fund Appropriations (WSL GFA)
Wyoming Wildlife – The Foundation (WW-TF)

OVERVIEW OF NONGAME PROGRAM PROJECTS AND FUNDING SOURCES

Species or project	BLM CA	BOR CA	NPS CA	RCF	USACE	USFWS CA	USFWS S6	USFWS SWG	USFS CA	USFS RMRS	WAFWA	WGFD	WG ESAF	WSL GFA	WW-TF
Black-footed Ferret							X	X						X	
Trumpeter Swan	X					X								X	
Secretive Marsh Birds														X	
Bald Eagle monitoring					X									X	
Peregrine Falcon productivity						X								X	
Avian grassland SGCN												X	X	X	
Bat hibernacula and surveillance								X						X	
Bats – cliffs and caves inventory								X						X	
Bats – WNS risk assessment								X						X	
Wolverine distribution														X	
Falconry	X											X			
Breeding Bird Survey	X	X	X			X			X					X	
WYPIF and IMBCR	X		X					X	X					X	
White-tailed Prairie Dog range-wide surveys						X		X						X	

Species or project	BLM CA	BOR CA	NPS CA	RCF	USACE	USFWS CA	USFWS S6	USFWS SWG	USFS CA	USFS RMRS	WAFWA	WGFD	WG ESAF	WSL GFA	WW-TF
White-tailed Prairie Dog SPV								X			X			X	
Black-tailed Prairie Dog statewide inventory													X		
Central Flyway NMBTC												X		X	
WY Bird Records Committee	X													X	
WY Bat Working Group								X						X	X
Common Loon				X											
Ferruginous Hawk										X					
Long-billed Curlew tracking								X						X	
Great Gray Owl								X							
Black-backed Woodpecker													X		
Songbirds and energy development impacts								X							
Shrews								X						X	
American Pika								X							
Clarifying exposure risk of small mammals													X		
Grassland small mammals								X							

PREFACE

Most Wyoming residents and visitors know and cherish the thought of the state being rich in wildlife diversity. There is strong public interest in wildlife conservation and, along with that interest, high expectations. A 2011 national survey by the U.S. Fish and Wildlife Service (http://digitalmedia.fws.gov/cdm/singleitem/collection/document/id/858/rec/10) found that, in addition to $797 million spent on hunting and fishing in Wyoming, over $350 million was added to the state's economy by wildlife watchers. Wyoming is also rich in other natural resources that contribute to our economy, such as oil, gas, coal, livestock forage, timber, and a variety of minerals. However, sometimes the best management of one or more resources can conflict with the needs of another.

Over the past few decades, public expectations of wildlife managers have diversified. Unfortunately, traditional funding sources were not sufficient to meet these new demands. In 2005, Wyoming's Legislature approved general fund appropriations for the Wyoming Game and Fish Department's (Department) Veterinary Services section, Greater Sage-Grouse conservation, and fisheries work. In 2008, Wyoming's Legislature and former Governor Freudenthal agreed to increase appropriations to fund the Department's Terrestrial Nongame Program in order to boost data collection and strengthen management for Wyoming's nongame species, particularly those considered sensitive. In the following biennium budget sessions, funding for these Department programs, as well as the Wyoming Wildlife and Natural Resources Trust, has continued. Funding of nongame efforts is a significant and progressive expansion of the Legislature's support for natural resources in Wyoming. The expectation that accompanies such funding is to develop the information base and expertise to allow for effective decision making associated with resource management and to avoid unnecessary conflicts and restrictions.

These expectations are similar to the expectations associated with the Department's past portfolio of funding sources for nongame, but they are more targeted. In the past, the Department's nongame efforts were funded primarily by user fees collected from hunting and fishing. Many of the hunting and fishing public recognizes that sound management of nongame fish and wildlife helps provide additional support for maintaining functioning ecosystems for game species. Yet, for most of us, there is a limit to how user fees should be spent on management of non-target wildlife.

Over the past two decades, at both the national and state level, a number of efforts have focused on find alternate funding for nongame species conservation. Many of the same individuals contributing to Wyoming's economy through expenditures associated with hunting, fishing, and wildlife watching were, no doubt, involved in intense national lobbying efforts to develop nongame funding.

In response, Congress established the federally funded State Wildlife Grants (SWG) program in 2000. Since then, the Department has received over $6 million of SWG funds to address data needs for nongame birds, mammals, fish, amphibians, and reptiles, and to collect information that may provide an early warning of species heading for a potential listing under the

Endangered Species Act. Most states tended to focus SWG projects on species that would grab the attention of supporters and Congress who debate federal budgets on an annual basis. But the expectations associated with SWG also extend to species like the American pika or Harlequin Duck that are high on the interest scale for wildlife watchers but have little potential for conflict with other resource users because of the habitats they occupy in the state.

During the early years of SWG funding, we tended to focus on planning efforts that produced documents such as the Trumpeter Swan Habitat Enhancement Project, Wyoming Bird Conservation Plan, A Plan for Bird and Mammal Species of Greatest Conservation Need in Eastern Wyoming Grasslands, and A Comprehensive Wildlife Conservation Strategy in Wyoming. The latter planning document, approved in 2005, provides guidance for development of more recent SWG proposals and was the foundation for the Wyoming State Wildlife Action Plan 2010, and the Wyoming State Wildlife Action Plan 2017, In Press. We have used SWG funding to develop and implement inventory methods for sensitive species, such as raptors, Harlequin Duck, American Bittern, Mountain Plover, Brewer's Sparrow, Sagebrush Sparrow, Sage Thrasher, swift fox, and northern flying squirrels. We have also used SWG funds to collect additional information on American pika; several species of bats; Canada lynx; fisher; northern river otter; pygmy rabbit; black-tailed and white-tailed prairie dogs; wolverine; and small mammals, including shrews and water voles.

Funding provided by the Wyoming State Legislature, Wyoming Governor's Endangered Species Account, and Western Association of Fish and Wildlife Agencies, as well as cooperative agreement funds from the Bureau of Land Management, US Fish and Wildlife Service, and US Forest Service, have greatly enhanced our ability to collect information on numerous species in Wyoming, including Species of Greatest Conservation Need. These funds have given us the opportunity to greatly increase our knowledge of distribution and abundance of these species, as well as allowing us to increase our understanding of what is needed for effective and proactive management of those species. These funds have also allowed us to work cooperatively with other entities, such as the University of Wyoming, Wyoming Natural Diversity Database, Bird Conservancy of the Rockies (formerly Rocky Mountain Bird Observatory), Audubon Rockies, and private contractors, as well as interested volunteers, to implement projects that will provide population status and trend information on additional Species of Greatest Conservation Need, such as the Ferruginous Hawk, Golden Eagle, Burrowing Owl, Upland Sandpiper, Grasshopper Sparrow, pocket mice, Preble's meadow jumping mouse, wolverine, and Wyoming pocket gopher. Finally, we have also had the opportunity to implement funds provided by the US Fish and Wildlife Service, including Section 6 funds, for several additional projects, such as a collaborative survey effort for Northern Goshawks in the Wyoming Range, a study to determine the potential effects of energy development on raptor populations in Wyoming, and systematic monitoring of white-tailed prairie dogs and the reintroduced population of black-footed ferrets in Shirley Basin.

The future remains uncertain as we progress through difficult economic times. Anthropogenic and environmental stressors, such as climate change, will undoubtedly continue to put a strain on the Department's ability to effectively meet our statutory mandate to manage all wildlife in Wyoming. In conjunction with our partners, we will continue this collaborative endeavor to conserve this unique and diverse resource on behalf of the citizens of Wyoming.

INTRODUCTION

The Nongame Program of the Wyoming Game and Fish Department (Department) was initiated in July 1977. This report summarizes the most recent nongame bird and mammal work conducted in Wyoming from 15 April 2015 through 14 April 2016, although the complete coverage of some work may be slightly outside of this reporting period. Nongame surveys and projects in this report have been conducted by Department personnel, other government agencies, non-governmental organizations, and individuals in cooperation with the Department. Cooperating agencies and individuals are listed in the individual completion reports, but we recognize that the listing does not completely credit the valuable contributions of the many cooperators, including Department Regional personnel and members of the public.

In October of 1987, a Nongame Strategic Plan was distributed; this plan was updated and renamed in May of 1996. The 1996 Nongame Bird and Mammal Plan (Plan) presents objectives and strategies for the management and study of nongame birds and mammals in Wyoming. As part of the State Wildlife Grants funding program to provide long-term conservation planning for those species most in need, information was gleaned from the Plan and other pertinent sources and compiled into A Comprehensive Wildlife Conservation Strategy for Wyoming, which was approved by the Wyoming Game and Fish Commission (Commission) on 12 July 2005. This has since undergone a 5-year revision, was renamed the Wyoming State Wildlife Action Plan, and was approved by the Commission in 2010, with a second revision currently occurring and expected to be completed in 2017. This Nongame Annual Completion Report presents information in 6 major sections that compliment these planning efforts: Threatened and Endangered species, Species of Greatest Conservation Need, raptors taken for falconry, other nongame surveys, technical committees and working groups, and an appendix that contains reports from other entities on projects that were conducted with Department assistance.

Legislative funding has enabled the Department to significantly expand nongame and sensitive species conservation efforts, enhancing our ability to inventory, initiate monitoring, and assess the status of many species of wildlife classified as sensitive in 2010. The FY09/10 biennium budget provided general fund appropriations to the Department for the first time for all aspects of its nongame/sensitive species program: $1.2 million Maintenance and Operations (M&O) budget for existing personnel and administrative support and $609,000 in direct general fund appropriations for sensitive species program projects. In addition, $1.3 million from the Governor's Endangered Species Account fund was provided to the Department to supplement sensitive species project work. We also used several sources of federal funding for specific projects. General fund appropriations for M&O were essential for normal duties and for personnel to manage all of the special projects in this report. Specific funding sources in addition to M&O budgets are identified for each specific report.

This proactive approach is Wyoming's most effective strategy in reducing the chance that a species will be listed as Threatened or Endangered under the federal Endangered Species Act. The Department's Nongame Program is geared toward collecting information that has practical application for understanding the status of each species, as well as identifying potential risks and management actions that may be needed to secure the healthy status of those species needing some help.

This report serves several purposes. First, it provides summaries of nongame surveys for the benefit of the Department, other agencies, and individuals that need this information for management purposes. Second, it provides a permanent record of summarized data for future use. Although some of this information is in lengthy tables, it was felt that these data should be published rather than kept in the files of the Nongame Program staff. Some information, such as Bald Eagle and Ferruginous Hawk nest sites and bat roost locations, is sensitive and is not provided in this document. Those needing this information for purposes that will lead to better management of these species can request the data from the Nongame Program staff.

Common bird names used in this report follow the most recent American Ornithologists' Union guidelines and supplements. Mammal names follow the most recent Revised Checklist of North American Mammals North of Mexico.

THREATENED AND ENDANGERED SPECIES

SPOTLIGHTING FOR BLACK-FOOTED FERRETS IN THE SHIRLEY BASIN/MEDICINE BOW MANAGEMENT AREA

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need / Endangered Species – Black-footed Ferret

FUNDING SOURCE: United States Fish and Wildlife Service Section 6 Funds
United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECTION DURATION: Annual

PERIOD COVERED: 15 April 2015 – 14 April 2016

PREPARED BY: Jesse Boulerice, Nongame Biologist

ABSTRACT

The black-footed ferret (*Mustela nigripes*) faces numerous challenges to recovery, including diseases, which remain the biggest threat to the persistence of the black-footed ferret in Shirley Basin, Wyoming. Releases of black-footed ferrets in the Basin were initiated in 1991 but were terminated in 1994 as a result of sylvatic plague and disease epizootics, which reduced abundance of its prey, the white-tailed prairie dog (*Cynomys leucurus*) within Primary Management Zone 1. During this period, the reintroduced population was characterized by slow population growth. However, the black-footed ferret survived this bottleneck, and the population increased exponentially from 2000-2006 before transitioning to logistical growth from 2006-2010. In 2013, a dramatic decline was observed, predicted to be due to low recruitment of prairie dogs during 2011-2012 due to drought conditions. In 2015, we spotlighted and captured black-footed ferrets in August and September following the same protocol as in previous years. We obtained a total of 78 observations of black-footed ferrets, and determined the minimum number alive to be 45 individuals based on a summation of discrete observations. We collected blood samples from 26 captured black-footed ferrets. All individuals were negative for plague, canine distemper, and tularemia. Our results indicate that the abundance of ferrets in 2015 is similar to that in 2013, suggesting that recovery remains ongoing but may be occurring at a slower rate than anticipated.

INTRODUCTION

In 1991, Shirley Basin, Wyoming was selected as the first reintroduction site for black-footed ferrets (*Mustela nigripes*; ferret) in the world. Shirley Basin was selected for reintroduction due to its extensive complex of white-tailed prairie dogs (*Cynomys leucurus*; prairie dog) and the high level of support from private landowners in the area. Between 1991 and 1994, 228 ferrets were released in Shirley Basin. Releases were terminated in 1994 as a result of sylvatic plague and canine distemper epizootics, which decreased abundance of prairie dogs within Primary Management Zone 1. During this period, the reintroduced ferret population was characterized by slow population growth. Few (i.e., ≤20) ferrets were located annually prior to 2000. However, spotlight surveys conducted between 2003 and 2006 estimated an annual growth rate of 35% (Grenier et al. 2007). Survey results documented an increasing population of ferrets within the Shirley Basin/Medicine Bow prairie dog complex (Grenier et al. 2006b). Because prairie dog distribution had increased in other portions of Shirley Basin where ferrets were believed to be absent, an additional 250 ferrets were released into areas north and south of Shirley Basin during the fall and winter of 2005, 2006, and 2007 (Grenier et al. 2006a, Schell and Grenier 2007).

Primary monitoring interests have remained focused on a small portion of the prairie dog complex totaling about 8,000 ha (Grenier 2008). By 2006, the population had grown rapidly within this area of interest to 229 (95% CI: 169-289; Grenier et al. 2009). Estimates from 2008 (240; 95% CI: 176-303) and 2010 (203; 95% CI: 137-270) suggested that population growth had begun to taper off, as rate of growth appeared to transition from an exponential to a logistical pattern (Van Fleet and Grenier 2009, 2011). Surveys in 2013 suggested that the population had declined dramatically to ≥39 individuals (Boulerice and Grenier 2014). Although the Wyoming Game and Fish Department (Department) expected that ferrets would recover following this decline (Boulerice and Grenier 2014), surveys were not conducted in 2014 due to financial restrictions and personnel turnover. In 2015, a large effort was conducted to evaluate the status of ferrets within the Shirley Basin complex. This report quantifies results of fall spotlight surveys in 2015. We compare estimates of abundance and serology results to previous years, and discuss the implications of our findings for recovery of the ferret in Shirley Basin, Wyoming.

METHODS

We conducted spotlight surveys in 2015 throughout the Shirley Basin complex, which included the areas east of Highway 478 that were surveyed in 2006, 2008, 2010, and 2013, as well as areas west of Highway 487 where the original releases in 1991-1994 occurred (Figure 1). We selected specific survey routes based on available resources, personnel, the interspersion of 2-track and other roads, and observed prairie dog density. We contacted all landowners for permission to trespass prior to the initiation of surveys. Due to a low number of captures, we did not use closed population models to estimate abundance of ferrets as in previous years. Instead, we estimated minimum number alive by summing all discrete observations of ferrets following guidelines outlined in Grenier (2008).

We surveyed for ferrets either on foot, by vehicle, or a combination thereof. Sampling plots accessible only by foot were approximately 121 ha in size, while those accessible by vehicle were approximately twice as large (i.e., approximately 242 ha). Actual size of the survey plots varied due to size and shape of the prairie dog colony, as well as other geographical boundaries (Grenier 2008). We did not survey colonies <61 ha (Figure 1). We surveyed from 2000-2300 hours and 0100-0600 hours in blocks of 3 consecutive nights (Grenier 2008, Grenier et al. 2009). To locate ferrets, we drove vehicles equipped with roof-mounted spotlights (Model RM 240 Blitz, Lightforce Professional Lighting Systems, Orofino, ID) along existing roads. Field personnel used a backpack spotlight unit (Walkabout Kit, Lightforce Professional Lighting Systems, Orofino, ID) to traverse portions of the colony that could not be surveyed from a vehicle.

After we located ferrets, we used an unbaited live trap to attempt to capture observed individuals (Sheets 1972). We checked traps hourly throughout the night, and removed all traps at sunrise. We transported captured ferrets to a mobile processing trailer, where we used isoflurane gas to anesthetize individuals (Kreeger et al. 1998). Ferrets were assigned to juvenile or adult age classes by palpation of the sagittal crest, examination of dentition and tooth wear, and determination of reproductive status (Thorne et al. 1985). We marked ferrets with passive integrated transponders (PIT tags; AVID Microchip I.D. Systems, Folsom, LA) and hair dye (Grenier 2008). We collected blood samples when possible. We vaccinated captured ferrets for sylvatic plague and canine distemper with vaccines provided by the National Ferret Conservation Center (Carr, CO). Following a brief recovery period, we returned the ferret to the burrow from which it was captured. We sent blood samples to the Colorado State University Veterinary Diagnostic Laboratory to test for the presence of sylvatic plague (*Yersinia pestis*), and to the Wyoming Game and Fish Department Wildlife Veterinary Laboratory to test for the presence of tularemia (*Francisella tularemia*) and canine distemper virus antibodies.

RESULTS

We spent 1,252.6 hours over 18 nights spotlighting for ferrets in August and September (Table 1). We surveyed a total of 11,088 ha. We recorded 78 observations of ferrets and determined the minimum number alive to be 45 individuals (Table 2). This amounted to a discrete ferret approximately every 27.8 hours. We detected ≥10 litters. We compared minimum number alive to previous years (Figure 2).

We captured 26 ferrets, comprised of 10 males and 16 females. One female was previously captured in 2013, while all other ferrets were captured for the first time in 2015. We collected blood samples from all captured ferrets. All blood samples were negative for plague, canine distemper, and tularemia. We detected no abnormalities and very few (i.e., ≤10) ectoparasites (i.e., fleas and ticks) on most ferrets handled in 2015. Capture details for all captured ferrets are summarized in Table 3.

DISCUSSION

Based on our survey efforts in 2015, the minimum number alive for ferrets within the Shirley Basin complex appears to have remained similar to that in 2013 (Figure 2). These estimates represent a dramatic decrease of approximately 80% since the historical high rates reported in 2006-2010. Despite this decrease, all ferrets appeared to be in good physical and reproductive condition. We failed to detect any physical abnormalities among captured ferrets, and serology results suggested that ferrets we captured were not currently challenged with infectious diseases. We hypothesized in 2013 that the decline reported in that year may have been a result of poor recruitment of prairie dogs in 2011 and 2012 due to poor weather conditions, rather than poor health of individual ferrets (Boulerice and Grenier 2014). At that time, we noted that the population of prairie dogs within the complex appeared to be returning to normal, and predicted that the ferret population would recover accordingly. The consistency of the minimum number alive estimates between 2013 and 2015 suggests that this recovery remains ongoing but may be occurring at a slower rate than anticipated. As in 2013, we detected ≥10 litters of ferrets within the complex that appeared in good health, suggesting that ferrets continue to be reproductive and that the population continues to grow. Barring any suppressive weather events or disease outbreaks, we suspect that the population of ferrets will continue to recover slowly before undergoing exponential growth following a similar trend we observed at the Shirley Basin complex between 2000 and 2006.

We also note that the timing of some of our surveys in 2015 could have lowered our detection rates and thus underestimated abundance. Specifically, surveys conducted west of Highway 487 in early August may have been asynchronous with the optimal moon phase and reproductive timeline for detecting ferrets (Eads et al. 2012). Surveys were conducted during this time in an effort to maximize the total area surveyed in 2015, since no surveys were conducted in the previous year. However, we note that when a subset of this area was re-surveyed in mid-September, the location and number of ferret observations were consistent. Therefore, while the timing of some of the surveys could have reduced abundance estimates, we expect the difference to be minimal and the overall trend we documented to remain the same.

The decline in abundance we reported in 2013 and 2015, after the historical high numbers during 2006-2010, serves to illustrate the sensitivity of ferret populations to naturally occurring stochastic events. Disease outbreaks and weather events have had devastating impacts on prairie dogs and ferrets across North America, and mitigating these threats will continue to be a leading conservation challenge to ferret recovery (Black-Footed Ferret Recovery Implementation Team Subcommittee Meeting, personal communication). While the declines we have observed at the Shirley Basin complex are not ideal, the cyclic nature of prairie dogs and ferrets is not unexpected. For over 25 years, ferrets have survived at Shirley Basin under a minimal management strategy in spite of these inherent challenges. While the Department will continue to monitor this population and take necessary action to ensure the continued existence of ferrets in Shirley Basin, the history of recovery at this site suggests that the ferret population may be capable of persisting on the landscape without additional management at this time.

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LITERATURE CITED

Boulerice, J. T., and M. B. Grenier. 2014. Spotlighting for black-footed ferrets (*Mustela nigripes*) in the Shirley Basin/Medicine Bow Management Area. Pages 23-34 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona and N. Cudworth, Editors). Wyoming Game and Fish Department, Lander, USA.

Eads, D. A., D. S. Jachowski, J. J. Millspaugh, and D. E. Biggins. 2012. Importance of lunar and temporal conditions for spotlight surveys of adult black-footed ferrets. Western North American Naturalist 72:179-190.

Grenier, M. B. 2008. Population biology of the black-footed ferret reintroduced into Shirley Basin, Wyoming. Thesis. University of Wyoming, Laramie, USA.

Grenier, M., L. Van Fleet, B. Oakleaf, T. Filipi, and J. Artery. 2006a. Black-footed ferret releases in the Shirley Basin/Medicine Bow Management Area, Wyoming, completion report. Pages 5-16 *in* Threatened, Endangered and Nongame Bird and Mammal Investigations (A. O. Cerovski, Editor). Wyoming Game and Fish Department, Cheyenne, USA.

Grenier, M., T. Filipi, and D. Webber. 2006b. White-tailed prairie dog mapping and black-footed ferret habitat evaluation in the Shirley Basin/Medicine Bow black-footed ferret management area, Wyoming, completion report. Pages 26-33 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. O. Cerovski, Editor). Wyoming Game and Fish Department, Lander, USA.

Grenier, M. B., D. B. McDonald, and S. W. Buskirk. 2007. Rapid population growth of a critically endangered carnivore. Science 317:779.

Grenier, M. B., S. W. Buskirk, and R. Anderson-Sprecher. 2009. Population indices versus correlated density estimates of black-footed ferret abundance. Journal of Wildlife Management 73:669-676.

Kreeger, T. J., A. Vargas, G. E. Plumb, and E. T. Thorne. 1998. Ketamine-medetomidine or isoflurane immobilization of black-footed ferrets. Journal of Wildlife Management 62:654-662.

Schell, R. L., and M. Grenier. 2007. Black-footed ferret releases in the Shirley Basin/Medicine Bow Management Area, Wyoming, completion report. Pages 5-16 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. O. Cerovski, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Sheets, R. G. 1972. A trap for capturing black-footed ferrets. American Midland Naturalist 88:461-462.

Thorne, E. T., M. H. Schroeder, S. C. Forrest, T. M. Campbell III, L. Richardson, D. E. Biggins, L. R. Hanebury, D. Belitsky, and E. S. Williams. 1985. Capture, immobilization, and care of black-footed ferrets for research. Pages 9.1-9.8 *in* Proceedings of the Black-footed Ferret Workshop (S. Anderson and D. Inkley, Editors). Wyoming Game and Fish Department, Cheyenne, USA.

Van Fleet, L., and M. Grenier. 2009. Spotlighting for free ranging black-footed ferrets in the Shirley Basin/Medicine Bow Management area, Wyoming, completion report. Pages 3-19 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. O. Cerovski, Editor). Wyoming Game and Fish Department Nongame Program, Cheyenne, USA.

Van Fleet, L., and M. Grenier. 2011. Spotlighting for black-footed ferrets in the Shirley Basin/Medicine Bow Management area, completion report. Pages 3-22 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (M. B. Grenier, Editor). Wyoming Game and Fish Department Nongame Program, Cheyenne, USA.

Table 1. Survey effort expended while spotlighting for black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming during the fall of 2015. A total of 1,252.6 hours of spotlighting was conducted by vehicle and on foot throughout white-tailed prairie dog (*Cynomys leucurus*) colonies.

Dates	Walking	Driving	Total
Aug. 3-5	86.1	135.7	221.8
Aug. 10-12	172.2	102	274.2
Aug. 17-19	124.1	75.3	199.4
Aug. 24-26	75.3	116.7	192.0
Aug. 31-Sept. 2	143.2	59.7	200.0
Sept. 8-10	66.6	98.7	165.3
Total	**667.5**	**585.1**	**1252.6**

Table 2. Capture details for 26 black-footed ferrets (*Mustela nigripes*) captured in Shirley Basin, Wyoming 2015. Blood samples were taken from all 26 of the captured black-footed ferrets. Vaccines for plague and canine distemper were administered to 12 and 13 individuals, respectively. In the age column, J = juvenile, A = adult, and U = unknown.

Pit tag	Date	Colony	Observer	Age	Sex	Weight (g)	Plague vac.	Distemper vac.
19055874	08/10/15	527-2	D. Lemon	J	F	741	N	N
19061835	08/10/15	527-2	D. Lemon	A	F	676	N	N
19063535	08/10/15	520-3	C. Thompson	A	F	644	N	N
19059595	08/11/15	527-2	D. Lemon	J	M	680	N	N
19062819	08/17/15	510-2	R. Nuss	A	F	656	Y	Y
50833627*	08/24/15	556-9	B. Zinke	A	F	671	Y	Y
19059780	08/24/15	556-9	B. Zinke	J	F	680	Y	Y
19057101	08/24/15	556-9	B. Zinke	J	F	708	Y	Y
19055586	08/24/15	556-6	L. Tafelmeyer	A	F	787	N	N
19058850	08/25/15	556-2	J. Wilson	A	M	948	N	N
19054306	08/25/15	556-5	N. Cudworth	A	F	721	N	N
19054613	08/25/15	556-9	B. Zinke	A	M	941	N	N
19063551	08/25/15	556-6	L. Tafelmeyer	J	F	690	N	N
19053345	08/25/15	556-6	L. Tafelmeyer	A	M	906	N	Y
19059875	08/25/15	556-6	L. Tafelmeyer	J	F	708	Y	Y
19053106	08/26/15	556-5	N. Cudworth	A	M	917	N	N
19066057	08/26/15	556-5	N. Cudworth	A	M	906	N	N
19060611	08/26/15	556-5	N. Cudworth	A	M	894	N	N
19066080	08/26/15	556-6	L. Tafelmeyer	J	M	882	N	N
19003772	08/31/15	559-1	A. Larson	A	M	947	Y	Y
19031877	08/31/15	559-1	A. Larson	J	F	690	Y	Y
19050513	08/31/15	559-1	A. Larson	J	F	644	Y	Y
19051261	08/31/15	559-1	A. Larson	A	M	961	Y	Y
40828528	09/02/15	559-1	A. Larson	A	F	648	Y	Y
40882881	09/08/15	567-1	L. Tafelmeyer	U	F	690	Y	Y
40827532	09/09/15	567-1	L. Tafelmeyer	A	F	716	Y	Y

***** = Recapture from 2013

Table 3. Complete list of all black-footed ferrets (*Mustela nigripes*) observed in Shirley Basin, Wyoming 2015. Discrete observations were determined based on guidelines outlined in Grenier (2008).

Date	Time	Colony	Observer	Discrete
08/04/15	2302	567-1	A. Grasmick	Yes
08/04/15	2302	567-1	A. Grasmick	Yes
08/10/15	0507	520-3	C. Thompson	Yes
08/10/15	0015	527-2	D. Lemon	Yes
08/10/15	0300	527-2	D. Lemon	Yes
08/10/15	0530	527-2	D. Lemon	No
08/10/15	0230	518-1	C. Smith	Yes
08/11/15	2030	527-2	D. Lemon	No
08/11/15	2035	527-2	D. Lemon	No
08/11/15	2045	527-2	D. Lemon	Yes
08/11/15	2359	527-2	D. Lemon	Yes
08/11/15	2359	527-2	D. Lemon	Yes
08/11/15	2359	527-2	D. Lemon	Yes
08/12/15	2358	519-1	A. Grasmick	Yes
08/12/15	2030	527-2	D. Lemon	No
08/12/15	0430	527-2	D. Lemon	No
08/17/15	0335	510-2	R. Kepple & R. Nuss	Yes
08/17/15	0440	510-2	R. Kepple & R. Nuss	Yes
08/18/15	2325	509-3	N. Cipoletti	Yes
08/19/15	0125	510-2	R. Kepple & R. Nuss	No
08/19/15	0125	510-2	R. Kepple & R. Nuss	Yes
08/19/15	0550	510-5	A. Grasmick	Yes
08/19/15	0550	510-5	A. Grasmick	Yes
08/19/15	0550	510-5	A. Grasmick	Yes
08/24/15	2229	556-9	B. Zinke	Yes
08/24/15	2340	556-9	B. Zinke	Yes
08/24/15	0240	556-9	B. Zinke	Yes
08/24/15	0526	556-9	B. Zinke	Yes
08/24/15	0543	556-5	N. Cudworth	No
08/24/15	0249	556-6	L. Tafelmeyer	Yes
08/25/15	0503	556-4	C. Stewart	No
08/25/15	0150	556-9	B. Zinke	No
08/25/15	0230	556-9	B. Zinke	Yes
08/25/15	0230	556-9	B. Zinke	No
08/25/15	2216	556-5	N. Cudworth	Yes
08/25/15	2306	556-5	N. Cudworth	No
08/25/15	2240	556-6	L. Tafelmeyer	Yes
08/25/15	2243	556-6	L. Tafelmeyer	Yes
08/25/15	0413	556-6	L. Tafelmeyer	Yes

Table 3. Continued.

Date	Time	Colony	Observer	Discrete
08/25/15	0130	556-2	J. Wilson	No
08/25/15	0400	556-2	J. Wilson	Yes
08/26/15	2200	556-4	C. Stewart	No
08/26/15	2355	556-9	B. Zinke	No
08/26/15	2044	556-5	N. Cudworth	Yes
08/26/15	2044	556-5	N. Cudworth	No
08/26/15	2044	556-5	N. Cudworth	Yes
08/26/15	2044	556-5	N. Cudworth	Yes
08/26/15	2044	556-5	N. Cudworth	Yes
08/26/15	0329	556-5	N. Cudworth	No
08/26/15	0329	556-5	N. Cudworth	No
08/26/15	0415	556-5	N. Cudworth	No
08/26/15	0542	556-5	N. Cudworth	No
08/26/15	2130	556-6	L. Tafelmeyer	Yes
08/31/15	0250	559-1	A. Larson	Yes
08/31/15	0300	559-1	A. Larson	Yes
08/31/15	0420	559-1	A. Larson	Yes
08/31/15	0425	559-1	A. Larson	Yes
09/01/15	2315	559-5	J. Wilson	No
09/01/15	0415	559-5	J. Wilson	Yes
09/01/15	0210	559-1	A. Larson	No
09/01/15	0345	559-1	A. Larson	No
09/01/15	0350	559-1	A. Larson	No
09/01/15	2315	556-10	A. Grasmick	No
09/02/15	1130	559-5	J. Wilson	Yes
09/02/15	0215	559-5	J. Wilson	No
09/02/15	0426	555-1	Z. Walker	Yes
09/02/15	0205	559-3	M. Schuman	Yes
09/02/15	2115	559-1	A. Larson	Yes
09/02/15	0405	559-1	A. Larson	No
09/02/15	0425	559-1	A. Larson	No
09/02/15	0549	559-1	A. Larson	No
09/02/15	0549	559-1	A. Larson	No
09/02/15	0549	559-1	A. Larson	No
09/08/15	2100	567-1	L. Tafelmeyer	No
09/09/15	2230	567-1	L. Tafelmeyer	Yes
09/09/15	2240	567-1	L. Tafelmeyer	Yes
09/10/15	0420	567-1	A. Hicks	No
09/10/15	0425	567-1	A. Hicks	No

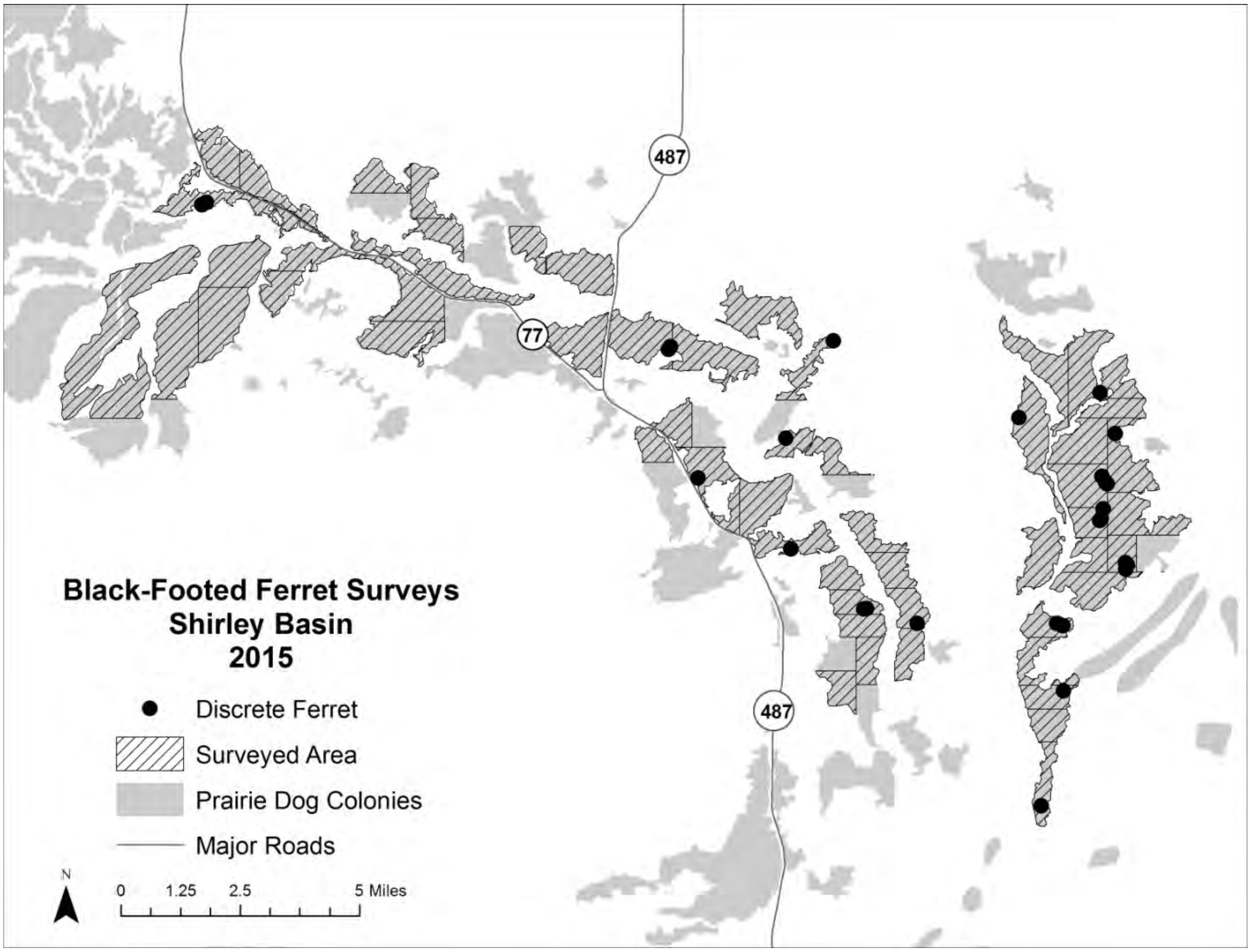

Figure 1. Spatial arrangement of discrete observations of black-footed ferrets (*Mustela nigripes*) and of white-tailed prairie dog (*Cynomys leucurus*) colonies that were surveyed in Shirley Basin, Wyoming, 2015.

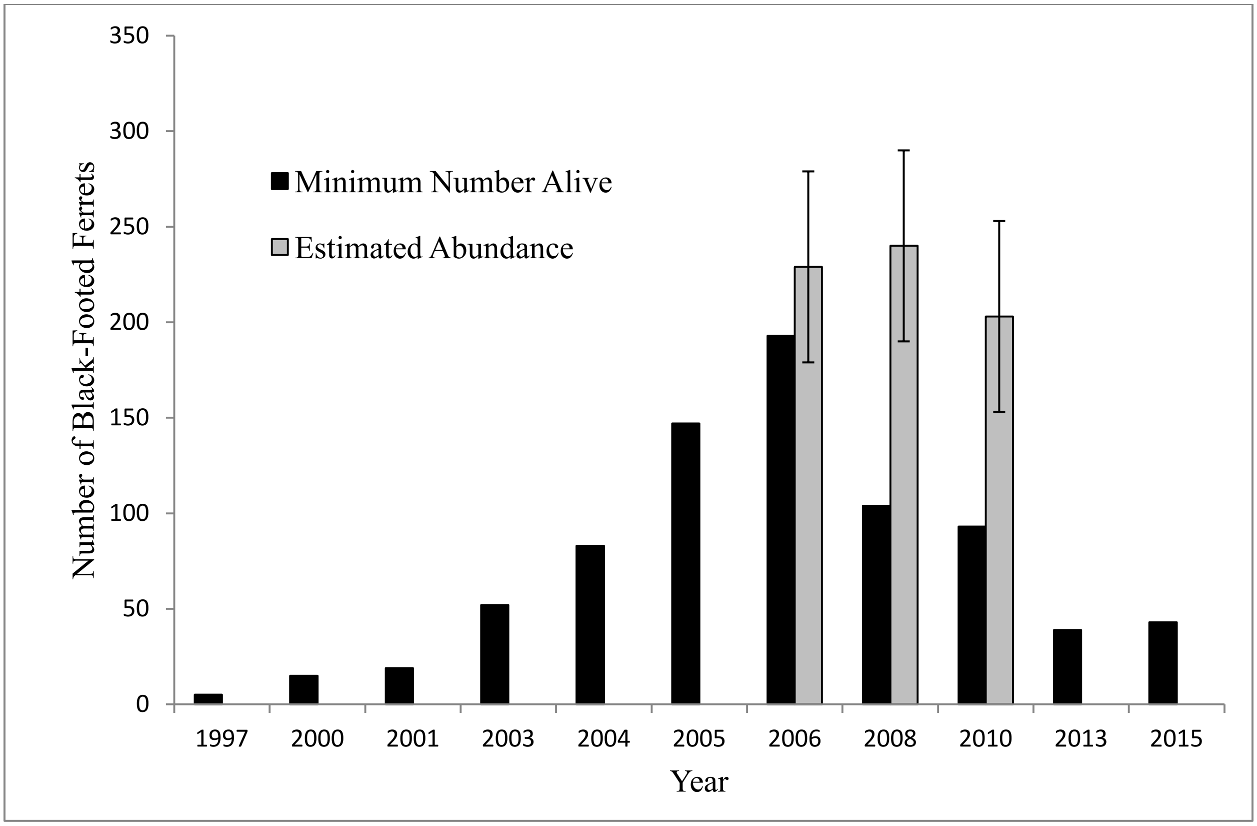

Figure 2. Abundance of black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming, 2000-2015. In 2006, abundance was estimated at 229 (95% CI: 169-289), in 2008 at 240 (95% CI: 176-303), and in 2010 at 203 (95% CI: 137-270). In 2013, 2015, and all years prior to 2006, abundance was based on minimum number alive, because number of captured ferrets was too low to estimate abundance. Surveys were not conducted in years not represented in the figure.

SPECIES OF GREATEST CONSERVATION NEED – BIRDS

MONITORING AND MANAGEMENT OF THE ROCKY MOUNTAIN POPULATION OF TRUMPETER SWANS (*CYGNUS BUCCINATOR*) IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Trumpeter Swan

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Bureau of Land Management Cooperative Agreement
United States Fish and Wildlife Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2015 – 14 April 2016

PREPARED BY: Susan Patla, Nongame Biologist

ABSTRACT

Since the late 1980s, the Wyoming Game and Fish Department has been actively involved in monitoring and managing Trumpeter Swans (*Cygnus buccinator*). The Trumpeter Swan is one of the rarest avian species that nests in Wyoming, and is classified as a Species of Greatest Conservation Need with Native Species Status of 2 by the Wyoming Game and Fish Department. Year-round resident Trumpeter Swans in Wyoming comprise part of the historic Tri-State population that nests in the Greater Yellowstone Area. Monitoring efforts for this species are coordinated with the US Fish and Wildlife Service, Pacific Flyway Council, and the state agencies in Idaho and Montana. We completed 4 survey flights to collect census data on total number of adults and young in summer and winter and to document occupancy and productivity of all known nest sites. In the 2015 fall survey, we documented an increase in resident adult and cygnet Trumpeter Swans in Wyoming outside of Yellowstone National Park compared to the previous year (*n* = 212 adults, 65 cygnets), which is a record high for the state. We also documented a record high number of occupied nest sites (*n* =57), which is the largest number since we initiated surveys in the 1980s. In February 2015, we counted a total of 1,075 swans in the Pacific Flyway area of Wyoming and 47 in the Central Flyway. This was a 13% increase compared to the previous winter. Fifty-one percent of wintering swans were located in the Snake River drainage. Growth of the resident population of Trumpeter Swans can be attributed to the Wyoming Game and Fish Department's range expansion efforts beginning in the late 1980s in the Salt and Green River Basins. We remain concerned over the slow decline in number and productivity of swan nest sites in the core Snake River area. To accommodate the growing number of nesting swans in the Green River Basin, we initiated a wetland habitat program in 2004 that focuses on cooperating with landowners to develop shallow-water wetland ponds that provide additional summer habitat for swans and other wildlife species. Work has

been completed on 5 private ranches, and >20 ha of shallow wetland habitat have been created in Sublette County. Funding for this work has been obtained by the Bureau of Land Management Wyoming Landscape Conservation Initiative (WLCI), Wyoming Wildlife and Natural Resource Trust (WWNRT), Natural Resources Conservation Service (NRCS), and the US Fish and Wildlife Service Partners Program. The success of this swan-focused wetland program has helped to stimulate other wetland-related projects in the Green River area. The Wyoming Game and Fish Department is currently administrating a standard North American Wetlands Conservation Act grant proposal developed with The Conservation Fund and other partners to obtain $1 million for conservation easements and wetland habitat projects in the Green River Basin. Another project started in 2012 and completed in 2015 was the first basin-wide wetland assessment funded by the Environmental Protection Agency states program in Wyoming for the Green River Basin.

INTRODUCTION

The Trumpeter Swan (*Cygnus buccinator*; swan) is designated as a Species of Greatest Conservation Need in Wyoming with Native Species Status ranking 2 (WGFD 2010). Although swans were never listed under the Endangered Species Act of 1973, they have been a focal management species for federal and state agencies in the Greater Yellowstone Area (GYA) or the Tri-State Area since the establishment of Red Rock Lakes National Wildlife Refuge in Montana in 1932. This refuge was created to conserve approximately 70 swans in the GYA, which were believed to be the last remaining Trumpeter Swans in the world. Due to conservation efforts, the number of swans in the GYA increased to >600 by the 1950s (USFWS 1998). However, the population has fluctuated greatly since that time hitting a low of 239 white birds (adults and subadults) in 1994. The total number of adult birds in the GYA exceeded 500 white birds in 2015 for the first time since 1967 (Olson 2016). This non-migratory segment of the population remains of concern even though Trumpeter Swan populations in Alaska, interior Canada, and the mid-western states have been increasing (Groves 2012).

The Pacific Flyway Council coordinates management of this population and has designated swans that nest and reside year-round in the GYA, including western Wyoming, as the Tri-State Area Flocks (TSAF). The TSAF are managed as part of the US segment of the Rocky Mountain Population (RMP) of swans, which includes those that nest in interior Canada and migrate south to over-winter in the GYA (USFWS 1998). The Wyoming Game and Fish Department (Department) coordinates with the US Fish and Wildlife Service (USFWS) Mountain-Prairie Region Migratory Bird Office and the states of Idaho and Montana to census the number of mature swans and young of the year (i.e., cygnets) in the TSAF. Since the late 1980s, the Department has worked to expand summer and winter distribution of swans in Wyoming (Patla and Oakleaf 2004). These efforts have established a new nesting population in the Green River Basin. Since 2004, the Department has cooperated with willing landowners to restore and create summer habitat in the Upper Green River Basin to accommodate this expanding resident flock (Patla and Lockman 2004, Lockman 2005).

The Department is a member of the Greater Yellowstone Trumpeter Swan Working Group, which consists of state and federal agencies, non-governmental organizations, and interested citizens. The working group meets annually to review and discuss productivity trends and to coordinate management actions. Wyoming also coordinates with the Pacific Flyway RMP Trumpeter Swan Study Sub-committee. This report summarizes management activities and monitoring data for swans in Wyoming for the 2015 nesting season. The annual coordinated winter survey, which would have occurred in February 2016, was cancelled this year by the USFWS due to lack of funding.

METHODS

We conducted 4 fixed-wing airplane surveys to collect data on swans in western Wyoming. We used the same pilot and Scout airplane from Sky Aviation, Worland, to fly all surveys. Flying elevation averaged 30-70 m above ground level depending on terrain and surface winds; flight speed varied between 135-160 kph. During the survey, the observer counted white birds (i.e., adults and subadults) and gray cygnets. We obtained some data on pre-nesting birds during Bald Eagle (*Haliaeetus leucocephalus*) occupancy surveys 30 March. We surveyed swan nesting areas on 30 and 31 May to determine occupancy and again on 1 and 2 July to count number of young hatched (i.e., cygnets). The fall and winter surveys were coordinated by USFWS in the Tri-State area of Wyoming, Montana, and Idaho. We flew the Wyoming portion of the fall survey on 19 September 2015. A winter survey was conducted on 11 and 12 February 2015 but no winter survey was conducted in February 2016. Additional data were collected through site-specific ground surveys, reports provided by federal agencies, and observations from the public. We presented survey results and participated in the Greater Yellowstone Trumpeter Swan Working Group meeting from 17-18 February 2016 in West Yellowstone, Montana. The USFWS Mountain-Prairie Region Migratory Bird Office produced 2 reports summarizing results for the coordinated RMP surveys that included data collected in Wyoming (Olson 2015, 2016).

RESULTS

During February 2015, we counted a total of 1,075 swans wintering in the Pacific Flyway portion of Wyoming outside of Yellowstone National Park (YNP), which represents a 13% increase over the previous year (Table 1, Figure 1). The largest percentage of wintering swans in the Pacific Flyway area occurred in the Snake River (52%) and the Green River (23%) drainages (Table 1). An additional 47 swans were documented wintering in the Central Flyway portion of Wyoming, including Bull and Dinwoody Lakes (Figure 1). The number of swans wintering in the Pacific Flyway area in Wyoming increased 6.5% per year between 1972 and 2014 (Olson 2015). Increase in wintering birds is largely the result of continued growth of the migrant interior Canada population.

In fall 2015, we counted a record high number of white swans (adults and subadults) in Wyoming outside of YNP ($n = 212$; Table 2). This represents a 7% increase in adults from the previous survey year. The rate of growth in Wyoming (1993-2014) has increased by 2.7% per year ($P < 0.01$) for white birds and 7.4% ($P < 0.001$) for cygnets (Olson 2016). However, the long-term trend for total number of swans in the traditional Snake River core area (1999-2015) showed no trend during this period ($p = 0.96$; Olson 2016). Conversely, in the Green River expansion area, the number of swans has increased by 10% ($P < 0.001$) over this same time period (Olson 2016). Overall, the total TSAF fall count of white birds increased by 21% compared to the previous year (548 vs. 452) and number of cygnets increased by 28% (175 vs. 137). The TSAF have shown an annual increase of 2.2% for white birds ($P < 0.01$) and +3.6% for cygnets ($P <0.01$) between 1993 and 2014 (Olson 2016).

The number of nest sites occupied in 2015 in Wyoming outside of YNP ($n = 57$) represented a new record for Wyoming and greatly exceeded the 10-year mean (Table 3, Figure 2). The number of nesting pairs in 2015 increased from 29 to 40 (+38%). Overall it was an exceptional year for swan productivity. The number of young hatched in Wyoming outside YNP in 2015 increased by 29% and the number of fledged young increased by 20% compared to the previous year (Table 3). Of the 57 sites occupied in 2015, 70% of pairs initiated nesting, 49% hatched young, and 40% fledged at least 1 young. Overall, swans in the Green River Basin accounted for 67% of occupied sites and 85% of fledged young (Table 4). In the Snake River core area, 41% of cygnets that hatched did not fledge, compared to 14% of hatched young that did not fledge in the Green River. This trend of greater cygnet survivorship in the Green River expansion area has held for 7 out of the last 9 years.

Site-specific occupancy and productivity results for all known swan nest sites surveyed in Wyoming outside of YNP are presented in Appendix I. An analysis of site specific productivity data from 25 nest sites in the Snake River core area where swans attempted to nest at least once during the 12-year period (2004-2015) showed that only 3 territories produced young more than half of the years during this period (SP, unpublished data). Twenty percent of the sites ($n = 5$) produced no young. Pairs on the National Elk Refuge accounted for 35% of all productivity over this time period.

Summary of mortality data from 1991-2015 are presented in Table 5. We documented 14 mortalities in Wyoming in 2015. Necropsy results from the Wyoming State Veterinary Laboratory for carcasses submitted this past spring and summer have yet been finalized. Overall since 1998, the Department has documented a total of 339 swan mortalities. The cause of mortality could be identified in 30% of the specimens ,with collisions accounting for 44%, predation 26%, disease/parasites 17%, and shooting 13% (Table 5). Many swan carcasses found during winter and early spring are in emaciated condition or have been scavenged or decayed to the degree that necropsies are not possible.

DISCUSSION

The 2015 nesting season was exceptionally successful with swan numbers and productivity in Wyoming outside of YNP and in the overall GYA population reaching historic highs. The number and productivity of Trumpeter Swans nesting in Wyoming outside of YNP has increased in recent years largely as a result of population growth in the Green River expansion area. We continue to document a loss of nest sites and low productivity at many nest sites in the Snake River core area. We have documented a dramatic increase in the number of migrant swans from interior Canada wintering in the core area over recent decades. Migratory swans may be reducing available forage needed by resident swans in winter and early spring.

Generally, most migrant swans depart by the end of March or early April, leaving resident swans to forage on remaining aquatic vegetation until additional wetlands thaw and open. Especially in years with cold, late springs, when the thaw in some locations was delayed until late May or early June, available aquatic vegetation is in short supply during the pre-nesting period. We hypothesize that the increase in the number of wintering swans negatively impacts resident pairs in the core area as a result of depleted foraging habitat that is in very limited supply during late winter and early spring. This idea is supported by results in 2007, which was one of the warmest springs on record in Wyoming. Wyoming swans in that summer produced a record number of young (n = 31) in the Snake River core area. Access to supplemental food on private wetland ponds may be exacerbating the problem of increasing the number of swans in the Jackson area in winter by attracting and holding more swans.

In contrast, although the number of swans wintering along the Green River south of Fontenelle Dam has been increasing annually since 2003, we are seeing exponential growth in resident swan numbers and increasing productivity in the Green River expansion area. This indicates that winter and early spring resources are adequate to support the resident nesting population in this drainage. Swans that winter along the Green River below Fontenelle Dam start to move north as soon as the river begins to thaw above the dam in early to mid-March. These swans have access to a much larger extent of new foraging habitat along the Green River corridor in the pre-nesting season compared to resident swans in the core area whose winter and summer habitat is concentrated in the valley of Jackson Hole.

Swans in Wyoming now comprise over 35% of the total TSAF and, therefore, constitute an important component of the current GYA resident population. Although, the success of the Green River range expansion program has resulted in increased numbers of swans in that area of the state, we remain concerned about productivity in the traditional core area, including YNP. We will continue to work with members of the Greater Yellowstone Trumpeter Swan Working Group and the Pacific Flyway to monitor this situation and work toward the development of management projects and joint research proposals to investigate the reasons for this decline and to manage for a viable nesting population in the core Snake River drainage. In future years, we will continue to focus management efforts on cooperative habitat projects with willing landowners to improve and restore wetland habitats in the Green River, Salt River, and Snake River drainages as opportunities arise (Patla and Lockman 2004, Lockman 2005, WGFD 2010). Given the increasing number and productivity of swans in the Green River Basin and possible long-term drought conditions, it is important that the Department continues to be a leader in habitat improvement projects for swans and other wildlife associated with shallow water wetland habitat. In 2015, swans used wetland sites developed by the Department as cooperative projects with landowners at 4 locations in the Pinedale area. Funding for these projects was obtained through the WLCI, WWNRT, NRCS programs, and USFWS Partners Program. Construction was completed in fall 2015 on a wetland restoration project near Daniel, which was funded by a standard North American Wetlands Conservation Act grant that was awarded to the Department, the USFWS, and 14 other partners in 2012 for a total of $1 million for conservation easements and wetland habitat projects in the Upper Green River Basin. In 2012, we also obtained a state grant from the Environmental Protection Agency, in partnership with The Nature Conservancy (TNC) of Wyoming, to conduct the first basin-wide assessment of wetland habitat in the state for the Green River basin. The final report completed in 2015 will provide a more complete understanding of the types and condition of wetlands in the basin and help to focus future conservation and restoration work.

In summary, the future outlook for the resident Trumpeter Swan population in Wyoming is greatly improved compared to the status in the 1990s. We have increased the number and distribution of swans in the state, and have also increased the amount of wetland habitat important for swans and many other species of waterfowl and other wildlife. Certain risks, however, may be increasing for this species, some of which are likely related to climate change, including drought- and development-related habitat loss, new and increasing waterfowl diseases and parasites, expanding number of wintering swans, and growth in recreational water sports.

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LITERATURE CITED

Groves, D. J. 2012. The 2010 North American Trumpeter Swan survey. Unpublished report. US Fish and Wildlife Service, Division of Migratory Bird Management, Juneau, Alaska, USA.

Lockman, D. 2005. Wyoming Green River Basin Trumpeter Swan summer habitat project, February 14, 2005. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Olson, D. 2015. Trumpeter Swan survey of the Rocky Mountain population, winter 2015. US Fish and Wildlife Service, Migratory Birds and State Program, Mountain-Prairie Region, Lakewood, Colorado, USA.

Olson, D. 2016. Trumpeter Swan survey of the Rocky Mountain population, United States breeding segment, Fall 2015. (February 24, 2016). US Fish and Wildlife Service, Migratory Birds and State Program, Mountain-Prairie Region, Lakewood, Colorado, USA.

Patla, S., and D. Lockman. 2004. Considerations and prescriptions for the design, construction, and management of shallow water wetlands for spring through fall use by Trumpeter Swans. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Patla, S., and B. Oakleaf. 2004. Summary and update of Trumpeter Swan range expansion efforts in Wyoming, 1988-2003. Proceedings and Papers of the 19th Trumpeter Swan Society Conference, Richmond, British Columbia. North American Swans 32:116-118.

United States Fish and Wildlife Service [USFWS]. 1998. Pacific Flyway management plan for the Rocky Mountain population of Trumpeter Swans. Pacific Flyway Study Committee, Portland, Oregon, USA.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Number of Trumpeter Swan (*Cygnus buccinators*) adults and cygnets counted in Wyoming for the coordinated Tri-State winter survey in February 2004 through 2015. No winter surveys were conducted in February 2016. Results are shown for specific survey areas in Wyoming where wintering swans have been found. Occasional swans observed in the Platte River drainage are not included. Data for the entire Tri-State Area, which includes portions of southwestern Montana and southeastern Idaho, can be obtained from Olson (2015).

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	149	307	61	94	0	611
2004	Cygnet	33	18	17	23	0	91
	Total	182	325	78	117	0	702
	Adult	124	367	61	102	31	685
2005	Cygnet	30	109	20	35	2	196
	Total	154	476	81	137	33	881
	Adult	121	413	100	124	18	776
2006	Cygnet	14	58	13	37	3	125
	Total	135	471	113	161	21	901
	Adult	144	420	116	158	6	844
2007	Cygnet	25	84	30	35	6	180
	Total	169	504	146	193	12	1024
	Adult	65	316	109	174	4	668
2008	Cygnet	7	63	30	43	6	149
	Total	72	379	139	217	10	817
	Adult	88	321	160	133	24	726
2009	Cygnet	2	63	27	8	12	112
	Total	90	384	187	141	36	838

Table 1. Continued.

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	18	369	160	85	16	648
2010	Cygnet	5	56	30	12	8	111
	Total	23	425	190	97	24	759
	Adult	125	467	168	150	27	937
2011	Cygnet	42	138	51	32	8	271
	Total	167	605	219	182	35	1208
	Adult	51	488	210	109	27	885
2012	Cygnet	4	99	20	29	24	176
	Total	55	587	230	138	51	1061
	Adult	2	548	212	120	15	897
2013	Cygnet	0	120	30	20	8	178
	Total	2	668	242	140	23	1075
	Adult	24	411	261	123	41	860
2014	Cygnet	7	50	45	21	6	129
	Total	31	461	306	144	47	989
	Adult	111	472	211	93	39	926
2015	Cygnet	33	96	33	26	8	196
	Total	144	568	244	119	47	1122

Table 2. Fall survey results for the Tri-State Area Flocks of the Rocky Mountain Population of Trumpeter Swan (*Cygnus buccinator*) that are resident year-round in the states of Idaho, Montana, and Wyoming, 2007-2015 (Olson 2016). YNP represents Yellowstone National Park. YNP released 3 captive-raised swan cygnets on the Yellowstone River (Hayden Valley) in 2016; these are included in the totals below.

Year	Age group	Montana	Idaho	Wyoming YNP	Wyoming outside YNP	Tri-State total
2007	Adult	157	113	10	103	383
	Cygnet	41	15	0	59	115
	Total	198	128	10	162	498
2008	Adult	140	112	6	121	379
	Cygnet	7	5	2	34	48
	Total	147	117	8	155	427
2009	Adult	138	122	4	97	361
	Cygnet	21	21	0	33	75
	Total	159	143	4	130	436
2010	Adult	129	101	2	143	375
	Cygnet	30	29	0	48	107
	Total	159	130	2	191	482
2011	Adult	123	98	9	124	354
	Cygnet	40	12	0	37	89
	Total	163	110	9	161	443
2012	Adult	129	97	12	143	381
	Cygnet	96	30	4	48	178
	Total	163	127	16	191	559
2013	Adult	208	80	17	153	458
	Cygnet	26	28	7	52	113
	Total	234	108	24	205	571
2014	Adult	198	74	13	167	452
	Cygnet	57	23	5	56	141
	Total	255	97	18	223	593
2015	Adult	212	104	20	212	548
	Cygnet	60	47	6	65	178
	Total	272	151	26	277	726

Table 3. Occupancy and productivity data for Trumpeter Swans (*Cygnus buccinator*) nesting in Wyoming outside of Yellowstone National Park, 1992-2015. Shown are number of sites occupied, number of nesting pairs, number of pairs that hatched cygnets, number of pairs with fledged cygnets (i.e., mature young in September), total number of cygnets hatched, and number of cygnets fledged (counted in the fall survey) per year. The values in bold are those that have been changed to reflect corrections in historic data. [a] Production data include a site in the Green River drainage where eggs were collected and five 1-day-old young from Wyoming Wetlands Society's captive flock were successfully grafted to a pair in 2000, of which 4 fledged, and again in 2001, of which 5 fledged. Mean and standard deviation are shown for the 10-year period 2005-2014.

Year	Sites occupied (*n*)	Nesting pairs (*n*)	Pairs with hatchlings (*n*)	Pairs with fledglings (*n*)	Individuals hatched (*n*)	Individuals fledged (*n*)
1992	29	10	5	3	17	9
1993	24	11	7	5	15	8
1994	20	13	8	5	29	18
1995	22	12	7	5	25	15
1996	**23**	**12**	**7**	4	**17**	**6**
1997	26	**14**	**6**	4	**19**	17
1998	**23**	18	10	7	26	15
1999	**21**	15	6	6	19	12
2000 [a]	26	16	**11**	**10**	**42**	**31**
2001 [a]	28	17	**11**	**10**	**34**	**27**
2002	24	**11**	9	8	23	17
2003	26	18	13	11	42	35
2004	22	17	14	11	54	37
2005	24	16	11	10	38	35
2006	24	18	12	8	33	26
2007	35	26	20	18	74	59
2008	35	16	12	11	39	34
2009	32	24	15	11	50	33
2010	37	24	18	12	66	48
2011	44	25	18	15	51	38
2012	44	28	18	16	62	48
2013	51	34	29	20	86	52
2014	53	29	21	19	63	54
2015	57	40	28	23	81	65
10-year mean (SD)	**37.9** (10.1)	**24.0** (5.9)	**17.4** (5.4)	**14.0** (4.2)	**56.2** (17.0)	**42.7** (10.9)

Table 4. Comparison of Trumpeter Swan (*Cygnus buccinator*) nest-site occupancy and productivity data for core and expansion areas in Wyoming outside of Yellowstone National Park, 2007-2014. Expansion areas include drainages where the Wyoming Game and Fish Department worked to expand both summer and winter distribution by translocation of wild swans or release of captive-raised swans from 1986-2003 (Patla and Oakleaf 2004). Core area is where swans nested in the Snake River drainage and its tributaries prior to range expansion efforts. Number of young fledged refers to the number of mature young counted on the September aerial survey conducted annually. Successful pair refers to those nesting pairs that hatched young.

Drainage and year	Occupied sites (*n*)	Nesting pairs (*n*)	Broods hatched (*n*)	Individuals hatched (*n*)	Individuals fledged (*n*)	Individuals hatched per successful pair ($\bar{x}$)
Snake River Core						
2007	17	11	9	37	31	4.11
2008	15	7	4	13	13	3.25
2009	14	10	6	21	12	2.33
2010	15	8	6	24	12	4.00
2011	18	10	7	22	14	3.14
2012	18	9	6	18	9	3.00
2013	19	12	11	30	16	2.72
2014	14	9	8	27	19	3.38
2015	17	10	6	17	10	2.83
Green River Expansion						
2007	16	13	11	37	28	3.36
2008	18	9	8	26	21	2.62
2009	18	14	9	29	21	2.08
2010	21	15	12	42	36	3.50
2011	24	14	10	27	23	2.70
2012	24	16	12	44	39	3.67
2013	31	22	18	56	36	3.11
2014	38	20	13	36	35	2.77
2015	38	28	22	64	55	2.90
Salt River Expansion						
2007	2	1	0	0	0	0.00
2008	1	0	0	0	0	0.00
2009	1	1	0	0	0	0.00
2010	1	1	0	0	0	0.00
2011	1	1	1	2	1	2.00
2012	1	1	0	0	0	0.00
2013	1	Unk.	0	0	0	0.00
2014	1	1	0	0	0	0.00
2015	2	2	0	0	0	

Table 5. Summary of Trumpeter Swan (*Cygnus buccinator*) annual mortalities in Wyoming, showing age class and probable cause of death, 1991 through 15 April 2015. Mortality of cygnets includes only those lost following fledge counts in September, so does not include brood reduction during the nesting season. [a] Mortality total for years 1991-1995 is not broken out by individual years; the following years' data are recorded for 15 April through 14 April for each period, but also includes carcasses and remains found after snow melt in May. [b] Swans with all white plumage over one year of age; likely some yearlings are included in this group. [c] Age not determined for 15 reported mortalities this period; necropsy reports not completed on 14 specimens submitted to lab. [d] Summary statistics are calculated only for the years 1998/1990-2015/2016.

Year	Total mortality (*n*)	Adult mortalities[b] (*n*)	Yearling mortalities (*n*)	Cygnet mortalities (*n*)	Collision mortalities (*n*)	Predation mortalities (*n*)	Shot or trapping mortalities (*n*)	Infection/ parasite mortalities (*n*)	Unknown mortalities (*n*)
1991-1995[a]	38	21	0	17	12	4	10	1	11
1995-1996	11	9	0	2	5	0	2	0	4
1996-1997	8	3	0	5	4	0	0	0	4
1997-1998	5								
1998-1999	10	8	0	2	2	1	0	1	6
1999-2000	10	7	0	3	6	2	1	1	
2000-2001	34	18	4	12	6	5	0	0	23
2001-2002	14	8	3	3	3	2	0	0	9
2002-2003	12	6	2	4	1	1	2	0	8
2003-2004	38	21	7	10	3	5	0	5	25
2004-2005	9	3	2	4	0	6	0	0	3
2005-2006[c]	49	27		11	1	0	1	0	47
2006-2007	10	8	0	2	0	0	0	0	10
2007-2008	11	7	1	3	4	1	2	1	3
2008-2009	16	11	3	2	4	1	0	0	11
2009-2010	6	4	1	1	1	1	0	0	4
2010-2011	7	6	0	1	4	0	1	0	2
2011-2012	32	21	3	8	5	1	1	4	21
2012-2013	37	18	11	8	2		1		24
2013-2014	13	8	0	5	1		3	2	7
2014-2015	11	5	1	1	2			3	5
2015-2016	14	9	1	4	2				8
Total[d]	339	208	49	92	47	26	13	17	236

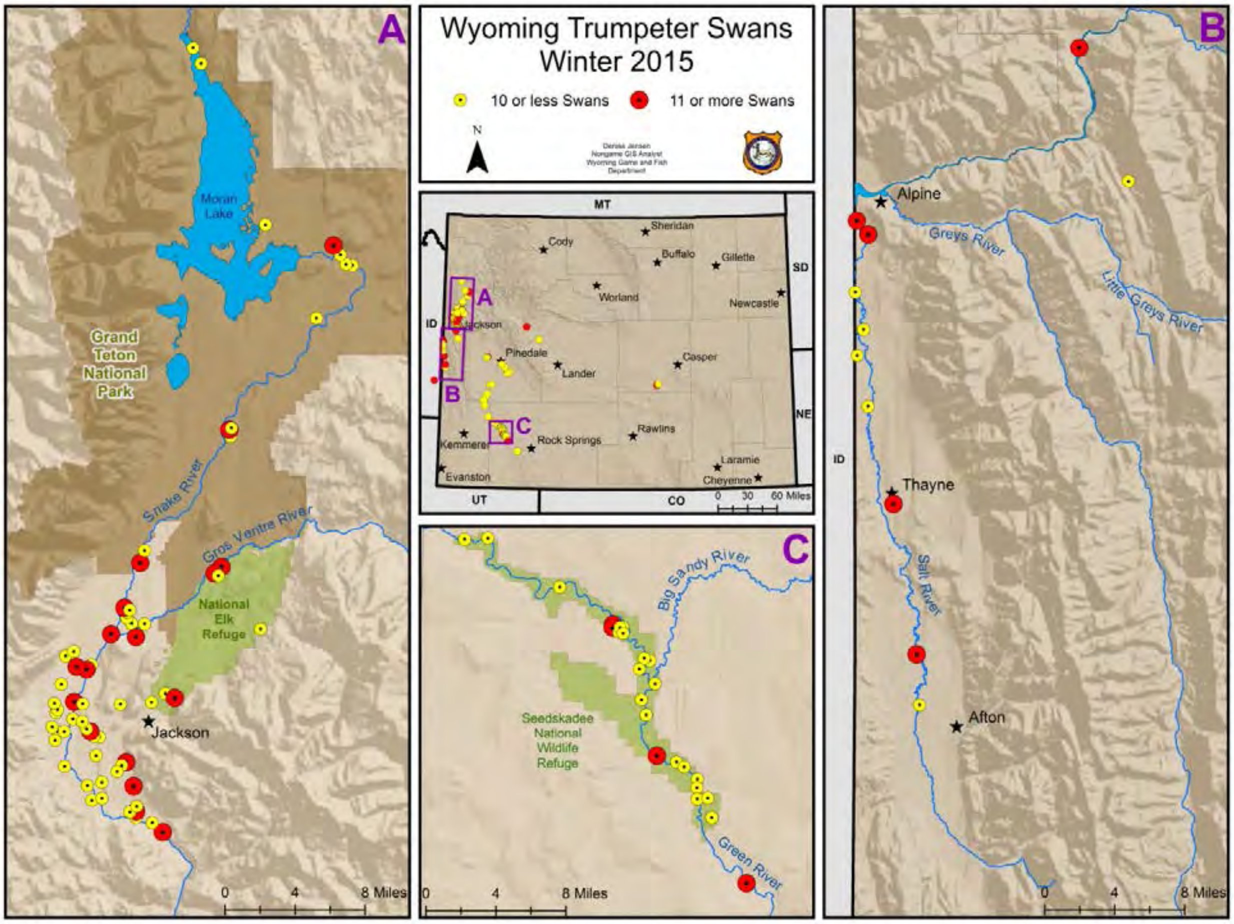

Figure 1. Locations of wintering Trumpeter Swans (*Cygnus buccinator*) in Wyoming documented during the annual winter aerial survey flown 11 February 2015 (Green River) and 12 February 2015 (Snake and Salt River drainages). Prior to management efforts beginning in the late 1980s to increase the distribution of swans in the Tri-State area, all swans wintered in the Jackson core area.

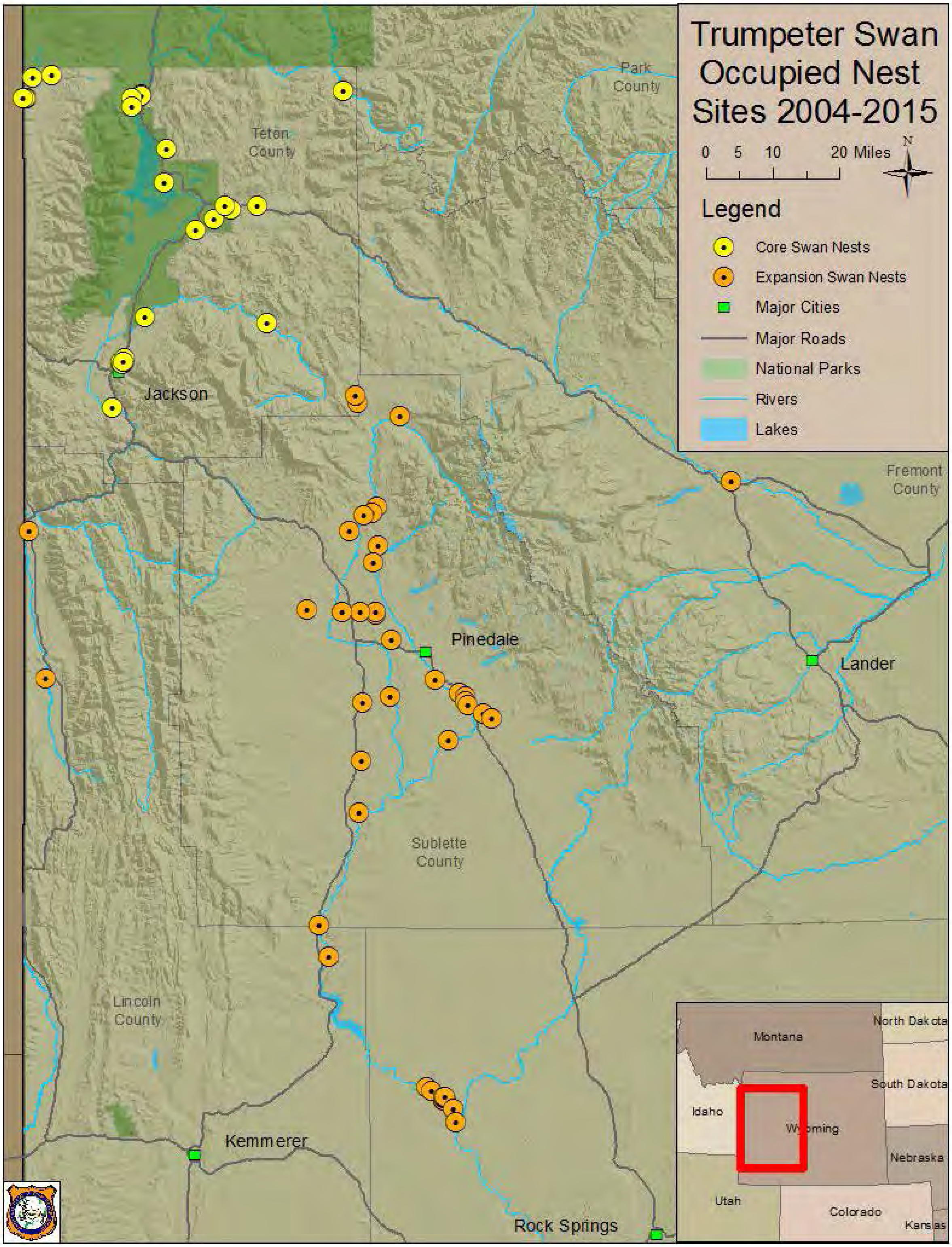

Figure 2. Locations of all wetland sites occupied at least one year by a pair of Trumpeter Swans (*Cygnus buccinator*) in Wyoming, 2004-2015 nesting seasons. Pairs did not build nests and lay eggs at all occupied sites. Yellows dots indicate sites located in the core Snake River area and orange dots show sites found in the range expansion area of Wyoming.

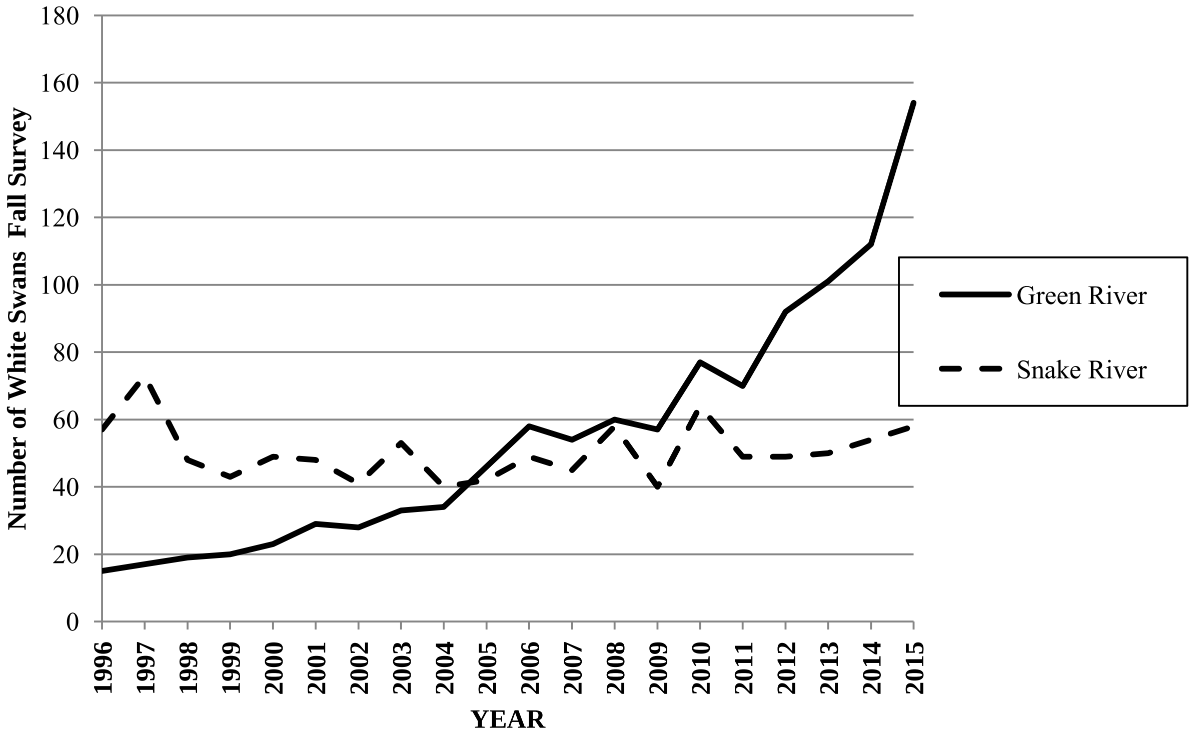

Figure 3. Comparison of the number of white swans (adults and subadults combined) counted on the annual fall aerial survey in September in the Snake River core area and the Green River expansion area in western Wyoming, 1996-2015.

Figure 4. Photo of adult Trumpeter Swan and 3 cygnets on the National Elk Refuge Flat Creek. One of the cygnets is a leucistic morph, which occurs in a few percent of Trumpeter Swans in Wyoming and the Greater Yellowstone area.

Appendix I. Annual summary of occupancy and production status for all known Trumpeter Swan (*Cygnus buccinator*) nests in Wyoming outside Yellowstone National Park, 2004-2014 by area. Sites include: CTNF – Caribou Targhee National Forest; GTNP – Grand Teton National Park; NER – National Elk Refuge; and Seedskadee NWR – Seedskadee National Wildlife Refuge. Key to the table codes includes: O – pair occupied site through nest period, did not attempt to nest, did not molt on site; OM – pair occupied territory through nest period, did not attempt to nest, molted on site; OL – pair occupied site late after nest initiation period; Nxy – pair nested, x = number of young hatched, y = number of mature young in September; OUID – pair reported on site but status not determined; NB – nonbreeding swans present, likely subadults; F – swans observed on fall (September) flight only; 1A – only one adult present; NS – not surveyed; --- – no swans observed all season.

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CTNF											
Ernest Lake	NB	---	---	---	---	---	---	---	---	---	---
Bergman Marsh	---	---	---	---	---	---	---	---	---	---	---
Indian Lake	N00	N10	N44	O	N40	N30	N30	N41	O	OL	NB
Widget Lake	---	---	---	---	---	---	---	---	---	---	---
Winegar Creek					N30	N20	N30	1A	N20	N40	N10
Fall River Slough			N00	---	---	---	---	---	---	---	---
Loon Lake	---	---	---	---	---	OL	---	---	---	---	---
Rock Lake	OM	N00	---	O	---	---	---	---	---	---	---
Rock Lake Slough						N41	---	---	---	1A	---
Junco Lake	---	N00	---	---	O	---	---	---	---	---	F
Fish Lake	---	---	---	---	---	---	---	---	---	---	---
Squirrel Meadows	OL	---	---	---	---	---	---	---	---	---	---
Moose Lake	---	---	---	---	---	---	---	---	---	---	---
GTNP											
Upper Glade	OM	---	---	---	---	---	---	---	---	---	---
Steamboat Mountain	---	N43	O	O	OL	O	O	OL	N21	O	---
Glade Cliff Slough	N00	N10	O	N00	O	O	O	N11	N22	N00	N33
Glade South	N00	O	O	---	---	---	---	---	O	---	F
Flagg Gravel Pit Ponds							---	---	O	---	---
Arizona Lake	N20	N40	N00	N00	N30	N20	N20	N00	---	O	OM
Emma Matilda	NB	NB	---	1A	OL	OL	OL	OL	O	---	O

Appendix I. Continued.

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GTNP (cont.)											
Swan Lake	NB	OL	OM	N22	O	OM	N55	O	O	O	OM
Christian Pond	---	---	---	---	---	---	---	---	---	---	---
Hedrick Pond	NB	1A	O	---	---	---	---	---	---	---	---
Elk Ranch	OM	OM	O	O	O	OL	OL	O	O	OM	OM
Spread Creek Ponds	---	---	---	---	---	---	---	---	N20	1A	---
Polecat Slough	---	---	---	1A	1A	---	---	---	---	---	---
NER											
Highway Pond NER	N00	---	N55	---	---	N00	---	---	---	---	---
NE Marsh NER	---	N32	NB	O	---	---	O		N22	---	OM
Flat Creek Island NER					N00	N10	N00	N00	N20	N53	N30
SE Marsh NER	O	N11	N42	N00	N11	---	O	N11		N11	
Central Marsh NER	N44	N33	N57	N33	O	N55	N00	N11	N22	N22	N32
Elk Jump Pond NER								N00	N00	N44	N00
Pierre's Ponds	O	OM	---	---	---	NB	O	---	---	OL	F
Romney Ponds	OL	NB	N44	N44	N43	NB	O	NB	1A	OL	OM
Bill's Bayou									OL	---	---
Jackson area											
Skyline/Puzzleface	NB	---	---	---	---	NB	NB	NB	OL	NB	O
WGF South Park	1A	OL	OM	OM	N44	N66	N44	N55	N43	N55	N55
Buffalo Valley											
Pinto/Halfmoon	N55	N33	N66	N44	N54	OM	N11	N00	N44	N44	N40
Halfmoon BV							N44	----	OL	---	1A
Blackrock slough								N60	N60	N20	N00
Tracy Lake				OL	OL	OL	OL	NB	NB	NB	NB
Lily Lake	---	---	---	---	---	---	---	---	---	---	---
Teton Wilderness											
Enos Lake	---	NB	NB	NB-3	---	NB	NB	NB	1A	1A	---
Atlantic Creek	---	---	---	---	nc	OUID	O	N00	N22	nc	N00

Appendix I. Continued.

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Salt River											
Kibby/Salt River Cove	NB	---	---	---	---	---	---	---	---	---	---
Alpine Wetland North	NB	NB	N00	---	NB	NB	NB	NB	NB	NB	NB
Alpine Wetland South			NB	O	N00	N00	N21	N00	O	N00	N00
Jacknife Creek area								O	---	---	---
Grover site											N00
Gros Ventre River											
Lower Slide Lake		---	---	---	---	NB	NB	---	NB	---	NB
Upper Slide Lake	N22	N00	OM	OM	OM	OM	O	O	O	O	O
Grizzly Lake pothole	---	Dry	Dry		---	---	---	---	---	---	---
Burnt Fork	---	---	---	---	NB	---	---	---	---	---	---
Soda Lake	---	---	---	---	---	---	---	---	---	---	---
Green/New Fork Rivers											
Wagon Creek Lake	---	---	---	NB	---	---	---	---	---	---	---
Rock Crib	---	---	---	NB	---	---	---	---	---	O	---
Wagon Creek Pothole			N00	---	---	N42	O	O	---	---	---
Mosquito Lake	---	NB	N32	N00	N00	O	OL	O	O	N22	N44
Pothole north of Mosquito											O
Roaring Fork Pond	---	---	---	---	---	---	---	---	---	---	---
Mud Lake	N20	N20	N52	OE	---	OL	O	N00	O	O	N33
Dollar Lake Slough											O
Circle S Slough						N00	---	NB	---	N11	N22
Jensen Pond, Green River								O	---	---	---
Carney Oxbow	N22	N00	N44	N00	N00	N22	N00	O	O	O	N22
Carney Pond					N30	---	---	---	---	O	N11
Q Y Bar Reservoir			O	O	---	---	---	---	---	---	---
O Bar Y Pond, new 2012								N44	N33	N44	N32
Marsh Creek Pothole			N22	---	---	---	---	---	---	---	---
Kendall Wetland	NB	NB	OL	N11	N33	OM	O	N44	N00	N22	N32

Appendix I. Continued.

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Green/New Fork Rivers (cont.)											
Blatt Res. Willow Creek								NB	O	O	NB
Kitchen Main	N22	N33	N54	N53	N11	N22	N32	N43	N00	N33	N44
Kitchen Middle	OM	OM	OM	O	N22	N55	N43	---	---	N43	O
Fenn Duck Creek Pond										O	N10
Seven Mile Ranch pond											O
40 Rod Creek Slough						F	NB	NB	N20	O	---
Vichory Reservoir								NB	N11	NB	O
Webb Draw						F	N00	N10	N22	N20	N20
MoCroft Lane, Pinedale								N00	---	O	N22
Fayette New Fork		NB	N33	N40	N00	---	N33	N55	N52	---	---
Swift New Fork				N54	OL	N33	OL	NB	NB	N00	N22
Barden Slough	OM	OM	---		---	---	---	---	---	---	---
Swift Reservoir	---	OL	OL	NB	NB	OL	O	N21	N33	N11	N21
EF Hunt Club/FH							N11	N21	N33	N00	N66
Jensen Slough North Fork				OL	O	N22	O	N21	O	N11	N00
Sommers Green River								O	N30	NB	---
Cottonwood Creek mouth								NB	---	---	---
Rimfire Rendezvous								NB	NB	NB	NB
Rimfire Sophia/Alexander								OL	NB	O	NB
Soaphole BLM Pond								NB	N44	NB	N44
Muddy Creek, N Big Piney								NB	---	O	N44
Bench Corral Reservoir #8										O	---
Ferry Island			N22	N33	N00	N44	OL	N22	N22	N22	N43
Shafer Slough	---	NB	---	---	NB	NB	---	NB	---	---	O
Reardon Draw							N11	NB	---	OL	---
Voorhees Pond	---	---	---	OL	---	N00	O	O	N40	O	NB
LaBarge Creek Pond							O	----	---	---	
Steed Canyon, new 2015											N00

Appendix I. Continued.

Site	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Green/New Fork Rivers (cont.)											
Big Sandy Reservoir	---	NS	---	nc	---	---	---	---	---	nc	NB
Eden Reservoir						1A	1A	NB2	---	nc	---
Farson area						N22	O	O	---	nc	NB
Seedskadee NWR											
Hamp Unit	N44	N53	O	N00	N00	N42	N42	N00	N22	N65	N55
Block House Isle., new 2015											N00
Hawley 1	N65	N54	N22	N33	N43	NB	O	N55	O	O	O
Hawley 2	N00	N66	N33	N66	N44	N55	N44	N66	N44	N20	N41
Hawley 2 S						N43	N33	---	N33	O	N00
Hawley 3	N33	---	NB	NB	---	NB	O	---	---	---	O
Hawley 5					N33	NB	NB	---	---	---	O
Hawley 6	N77	N00	NB	NB	---	N44	N22	N55	N22	N66	N44
Sage Pools			N31	N33	N75	N42	N22	N77	N55	N55	N22
Dunkle Wetland											N11
Big Island											NB
Other Wyoming											
Swamp Lake, Cody	---	---	---	NC	NC	NC	---	---	nc	nc	nc
Trail Lake, Dubois	OM	OM	---	---	---	---	---	---	---	---	nc
Dinwoody Lake						F	---	---	---	---	nc
Lake Julia						O	1A	---	---	---	nc
Martens Pond, Wind River							O	---	N55	N33	---
Alkali Lake, Wind River										NB	NB
Colony, eastern WY	NS	NS	---	---	NC	NC	OL	NB	---	nc	nc

EVALUATION OF MARSH HABITAT AND IMPLEMENTATION OF THE STANDARDIZED NORTH AMERICAN MARSH BIRD MONITORING PROTOCOLS FOR SPECIES OF GREATEST CONSERVATION NEED IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – American Bittern, Virginia Rail
Secretive Marsh Birds

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2015 – 14 April 2016

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

SUMMARY

The American Bittern (*Botaurus lentiginosus*) is classified as an uncommon summer resident in Wyoming (Orabona et al. 2012) and a Species of Greatest Conservation Need (SGCN) with a Native Species Status (NSS) 3, Tier II by the Wyoming Game and Fish Department because of severely limited wetland habitat necessary for reproduction and survival (WGFD 2010). Because of their secretive behavior, American Bitterns require a species-specific call-playback technique to document presence. In previous years, we used the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009) to conduct annual monitoring along 5 survey routes on the Cokeville Meadows National Wildlife Refuge (CMNWR; Refuge) in western Wyoming to determine presence and evaluate population trend of American Bitterns over time.

In 2015, we eliminated 3 of the survey routes on the CMNWR due to issues beyond our control (e.g., flooding, blocked access) and concern for human health and safety along the railroad right-of-way through a portion of the marsh habitat along which these surveys were located. However, due to willing participation by 2 landowners with property adjacent to the Refuge, we were able to add 2 new routes in place of the routes we eliminated for a total of 4 routes on the Refuge (Figure 1).

To better ascertain distribution and status of American Bitterns and other secretive marsh birds in Wyoming, we evaluated marsh habitat throughout the state to locate additional sites suitable for implementing the standardized survey methods for secretive marsh birds. We set up 6 new survey routes (Yellowtail Wildlife Habitat Management Area [WHMA], $n = 3$; Table

Mountain WHMA, *n* = 1; Dad Wetland, *n* = 1; and Hutton Lake NWR, *n* = 1) for a total of 10 routes in 5 wetland sites across Wyoming (Figures 2-12).

In 2015, we initiated an annual monitoring program for the American Bittern at these sites, and included 3 additional national marsh bird focal species: Pied-billed Grebe (*Podilymbus podiceps*), Virginia Rail (*Rallus limicola*), and Sora (*Porzana carolina*). Although the Virginia Rail and Sora are game species, there are currently no survey efforts in place to ascertain their distribution and occupancy in Wyoming. Furthermore, the Virginia Rail is classified as a SGCN NSS3, Tier II in Wyoming due to restricted population size and distribution (WGFD 2010).

Using the national secretive marsh bird call-playback technique will both standardize and add value to our survey efforts. Our results will be able to be compared with those from across the US where this method is also being employed, and our data will be added to the national marsh bird database to increase knowledge of species distribution and status on a larger scale. A summary of the species detected during the inaugural survey year is presented in Table 1.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature, for which the Department is extremely grateful. We would also like to express our appreciation to USFWS personnel at the Cokeville Meadows National Wildlife Refuge and Seedskadee National Wildlife Refuge for supporting our monitoring program and their continued efforts to improve wetland habitat at Cokeville Meadows to benefit Species of Greatest Conservation Need. Special thanks are extended to E. Pope and T. Teichert for supporting this monitoring program by giving us permission to conduct surveys on their private lands. Thanks to C. Conway, US Geological Survey, for assistance with questions regarding the Standardized North American Marsh Bird Monitoring Protocols. Finally, we thank Department personnel J. Altermatt, S. Tessman, and T. Mong for assistance with survey site locations and directions, and Department GIS Analysts D. Jensen and N. Whitford for producing the survey maps.

LITERATURE CITED

Conway, C. J. 2009. Standardized North American marsh bird monitoring protocols, version 2009-2. Wildlife Research Report #2009-02. US Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, USA.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State Wildlife Action Plan. Wyoming Game and Fish Department, Cheyenne, Wyoming, USA.

Table 1. Target species and additional species we detected during secretive marsh bird surveys on 10 routes in Wyoming, 2015. Surveys were conducted between 1 May and 15 June in lower elevations (north-central and eastern Wyoming), and between 15 May and 30 June in higher elevations (western Wyoming). We attempted to conduct 3 replicates per survey route, with a minimum of 2 weeks between each replicate. Morning surveys started by 0530 and ended by 0730. Evening surveys started by 2015 and ended by 2145. A key to species codes follows the table.

Route name (surveyor)	1st replicate 2015	Target species (number)	2nd replicate 2015	Target species (number)	3rd replicate 2015	Target species (number)	Other species detected
Dad Wetland (Tony Mong)	13 June	AMBI (1) PBGR (2) SORA (6) VIRA (0)	none	n/a	none	n/a	AMCO, BLTE, WFIB, CLGR, YHBL, EAGR, BUFF, RUDU, CITE, REDH, WIPH, BNST, KILL, NOHA, BCNH, COGO, CLSW, MAWR, AMAV
Pixley (Andrea Orabona)	4 June	AMBI (7) PBGR (2) SORA (6) VIRA (0)	17 June	AMBI (7) PBGR (1) SORA (11) VIRA (1)	none	n/a	AMCO, YHBL, RWBL, WEME, HOLA, SAVS, WILL, SACR, BNST, WISN, CITE, CAGO, NOHA, SPSA, VESP, MAWR, BARS, KILL, BHCO, COYE, NSHO, WFIB, GBHE; PSMA; CALA
Pope (Andrea Orabona)	5 June	AMBI (7) PBGR (0) SORA (3) VIRA (0)	19 June	AMBI (7) PBGR (0) SORA (9) VIRA (0)	none	n/a	AMCO, BAEA, BLTE, FOTE, YHBL, RWBL, SAVS, SACR, SPSA, KILL, HOLA, WEME, AMRO, MODO, EAKI, BRBL, BARS, LESC, CAGO, WFIB, WIPH, NOHA, CLSW, BNST, AMAV, YEWA, MAWR, MALL, WILL, LEFL, GBHE, PRFA, NSHO, CITE, CAGU, COYE, NOPI, SOSP, unidentified waterfowl; PSMA; CACA, ONZI, ODVI
Teichert (Andrea Orabona)	4 June	AMBI (10) PBGR (4) SORA (8) VIRA (0)	17 June	AMBI (19) PBGR (1) SORA (9) VIRA (1)	none	n/a	AMCO, YHBL, RWBL, WILL, SACR, SAVS, SPSA, WEME, CAGO, SWHA, MAWR, BARS, HOLA, KILL, BNST, WIPH, WFIB, SEOW, COYE, YEWA, unidentified waterfowl; PSMA

Table 1. Continued.

Route name (surveyor)	1st replicate 2015	Target species (number)	2nd replicate 2015	Target species (number)	3rd replicate 2015	Target species (number)	Other species detected
Thornock (Andrea Orabona)	2 June	AMBI (16) PBGR (2) SORA (11) VIRA (0)	16 June	AMBI (19) PBGR (2) SORA (17) VIRA (4)	none	n/a	AMCO, BLTE, FOTE, YHBL, RWBL, SAVS, NOHA, MAWR, BARS, CAGO, SWHA, WFIB, SACR, WILL, WISN, CANV, BCNH, DCCO, MALL, AMRO, CONI, COYE; PSMA; ONZI, MEME
Rush Lake (Kim Szcodronski)	16 May	AMBI (0) PBGR (5) SORA (0) VIRA (0)	31 May	AMBI (0) PBGR (5) SORA (0) VIRA (0)	12 June	AMBI (0) PBGR (7) SORA (0) VIRA (0)	AMCO, BCNH, WEGR, EAGR, WILL, YHBL, RUDU, MALL, CAGO; CACA, ANAM
Table Mountain (Kim Szcodronski)	16 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	31 May	AMBI (0) PBGR (2) SORA (0) VIRA (1)	13 June	AMBI (0) PBGR (2) SORA (0) VIRA (1)	AMCO, COLO, WEGR, AWPE, WFIB, GBHE, RWBL, YHBL, AMAV, KILL, WIPH, SPSA, EAKI, WEKI, WEME, COGR, GHOW, BHCO, RTHA, BWTE, CAGO, MALL, AMWI, NSHO, SACR, MODO; CYLU
Yellowtail East (Brian Zinke)	12 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	30 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	9 June	AMBI (0) PBGR (0) SORA (0) VIRA (0)	AMCO, COLO, WEGR, EAGR, AWPE, GBHE, RWBL, YHBL, VESP, KILL, BARS, NOFL, EAKI, BUOR, WEME, COGR, NOHA, AMCR, LASP, SPTO, GRCA, YEWA, CHSP, AMRO, LESC, WODU, CAGO, MALL, NSHO, SACR, MODO, RPHE, WITU; ALAL, PRLO
Yellowtail South (Brian Zinke)	6 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	30 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	9 June	AMBI (0) PBGR (0) SORA (0) VIRA (0)	RWBL, SACR, KILL, RPHE, MODO, CAGO, AMRO, NOHA; PSMA

Table 1. Continued.

Route name (surveyor)	1st replicate 2015	Target species (number)	2nd replicate 2015	Target species (number)	3rd replicate 2015	Target species (number)	Other species detected
Yellowtail West (Brian Zinke)	11 May	AMBI (0) PBGR (1) SORA (1) VIRA (0)	29 May	AMBI (1) PBGR (0) SORA (0) VIRA (1)	8 June	AMBI (0) PBGR (1) SORA (0) VIRA (1)	AMCO, RWBL, YHBL, SACR, WEME, NOFL, EAGR, COYE, AMRO, HOLA, RPHE, MODO, VESP, MALL, NSHO, KILL, CAGO, RTHA, GHOW, BARS, AWPE, COGR, EAKI, CHSP, AMCR, COME, CONI, WODU, REDH, CANV; PSMA; ODVI
Total routes = 10	*Highest total count of target species for all routes combined: AMBI = 54, PBGR = 20, SORA = 54, VIRA = 8*						*Total replicates conducted out of 30 = 24*

Key to species codes:

Species codes – target species	Common name	Scientific name
AMBI	American Bittern	*Botaurus lentiginosus*
PBGR	Pied-billed Grebe	*Podilymbus podiceps*
SORA	Sora	*Porzana carolina*
VIRA	Virginia Rail	*Rallus limicola*

Species codes – other species	Common name	Scientific name
ALAL	Moose	*Alces alces*
ANAM	Pronghorn	*Antilocapra americana*
AMAV	American Avocet	*Recurvirostra americana*
AMCO	American Coot	*Fulica americana*
AMCR	American Crow	*Corvus brachyrhynchos*
AMRO	American Robin	*Turdus migratorius*
AMWI	American Wigeon	*Anas americana*
AWPE	American White Pelican	*Pelecanus erythrorhynchos*
BAEA	Bald Eagle	*Haliaeetus leucocephalus*
BARS	Barn Swallow	*Hirundo rustica*
BCNH	Black-crowned Night-Heron	*Nycticorax nycticorax*
BHCO	Brown-headed Cowbird	*Molothrus ater*
BLTE	Black Tern	*Chlidonias niger*
BNST	Black-necked Stilt	*Himantopus mexicanus*
BRBL	Brewer's Blackbird	*Euphagus cyanocephalus*
BUFF	Bufflehead	*Bucephala albeola*
BUOR	Bullock's Oriole	*Icterus bullockii*
BWTE	Blue-winged Teal	*Anas discors*
CACA	Beaver	*Castor canadensis*
CAGO	Canada Goose	*Branta canadensis*
CAGU	California Gull	*Larus californicus*
CALA	Coyote	*Canis latrans*
CANV	Canvasback	*Aythya valisineria*

Species codes - other species	Common name	Scientific name
CHSP	Chipping Sparrow	*Spizella passerina*
CITE	Cinnamon Teal	*Anas cyanoptera*
CLGR	Clark's Grebe	*Aechmophorus clarkii*
CLSW	Cliff Swallow	*Petrochelidon pyrrhonota*
COGO	Common Goldeneye	*Bucephala clangula*
COGR	Common Grackle	*Quiscalus quiscula*
COLO	Common Loon	*Gavia immer*
COME	Common Merganser	*Mergus merganser*
CONI	Common Nighthawk	*Chordeiles minor*
COYE	Common Yellowthroat	*Geothlypis trichas*
CYLU	White-tailed Prairie Dog	*Cynomys leucurus*
DCCO	Double-crested Cormorant	*Phalacrocorax auritus*
EAGR	Eared Grebe	*Podiceps nigricollis*
EAKI	Eastern Kingbird	*Tyrannus tyrannus*
FOTE	Forster's Tern	*Sterna forsteri*
GBHE	Great Blue Heron	*Ardea herodias*
GHOW	Great Horned Owl	*Bubo virginianus*
GRCA	Gray Catbird	*Dumetella carolinensis*
HOLA	Horned Lark	*Eremophila alpestris*
KILL	Killdeer	*Charadrius vociferus*
LASP	Lark Sparrow	*Chondestes grammacus*
LEFL	Least Flycatcher	*Empidonax minimus*
LESC	Lesser Scaup	*Aythya affinis*
MALL	Mallard	*Anas platyrhynchos*
MAWR	Marsh Wren	*Cistothorus palustris*
MEME	Striped Skunk	*Mephitis mephitis*
MODO	Mourning Dove	*Zenaida macroura*
NOFL	Northern Flicker	*Colaptes auratus*
NOHA	Northern Harrier	*Circus cyaneus*
NOPI	Northern Pintail	*Anas acuta*

Species codes - other species	Common name	Scientific name
NSHO	Northern Shoveler	*Anas clypeata*
ODHE	Mule Deer	*Odocoileus hemionus*
ONZI	Common Muskrat	*Ondatra zibethicus*
ODVI	White-tailed Deer	*Odocoileus virginianus*
PRFA	Prairie Falcon	*Falco mexicanus*
PRLO	Northern Raccoon	*Procyon lotor*
PSMA	Boreal Chorus Frog	*Pseudacris maculata*
REDH	Redhead	*Aythya americana*
RPHE	Ring-necked Pheasant	*Phasianus colchicus*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RUDU	Ruddy Duck	*Oxyura jamaicensis*
RWBL	Red-winged Blackbird	*Agelaius phoeniceus*
SACR	Sandhill Crane	*Grus canadensis*
SAVS	Savannah Sparrow	*Passerculus sandwichensis*
SEOW	Short-eared Owl	*Asio flammeus*
SPSA	Spotted Sandpiper	*Actitis macularius*
SPTO	Spotted Towhee	*Pipilo maculatus*
SWHA	Swainson's Hawk	*Buteo swainsoni*
VESP	Vesper Sparrow	*Catharus fuscescens*
WEGR	Western Grebe	*Aechmophorus occidentalis*
WEKI	Western Kingbird	*Tyrannus verticalis*
WEME	Western Meadowlark	*Sturnella neglecta*
WFIB	White-faced Ibis	*Plegadis chihi*
WILL	Willet	*Tringa semipalmata*
WIPH	Wilson's Phalarope	*Phalaropus tricolor*
WISN	Wilson's Snipe	*Gallinago delicata*
WITU	Wild Turkey	*Meleagris gallopavo*
WODU	Wood Duck	*Aix sponsa*
YEWA	Yellow Warbler	*Setophaga petechia*
YHBL	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*

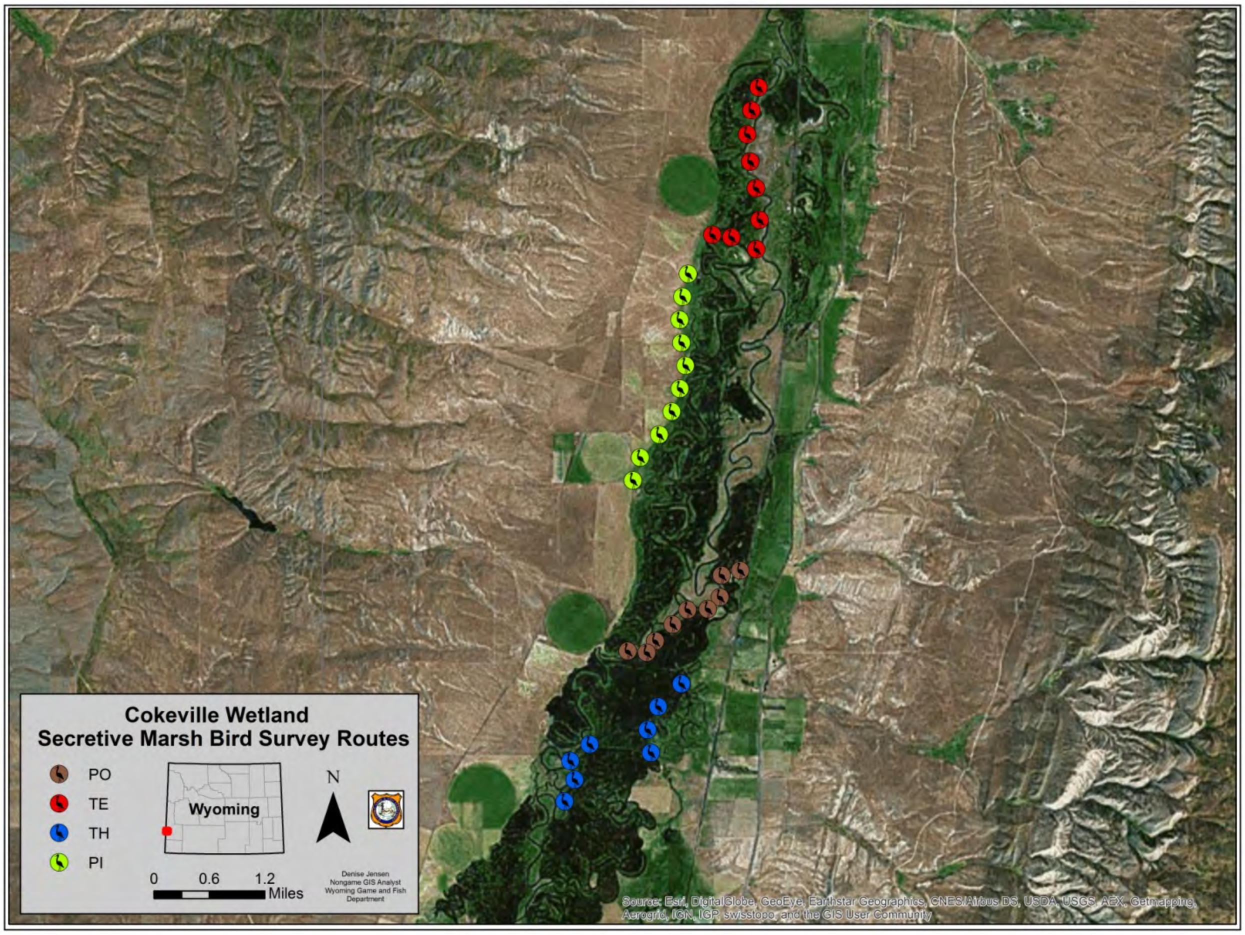

Figure 1. Locations of secretive marsh bird survey routes we established on and adjacent to the Cokeville Meadows National Wildlife Refuge in Wyoming using the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009). PO = Pope route, TE = Teichert route, TH = Thornock route, and PI = Pixley route.

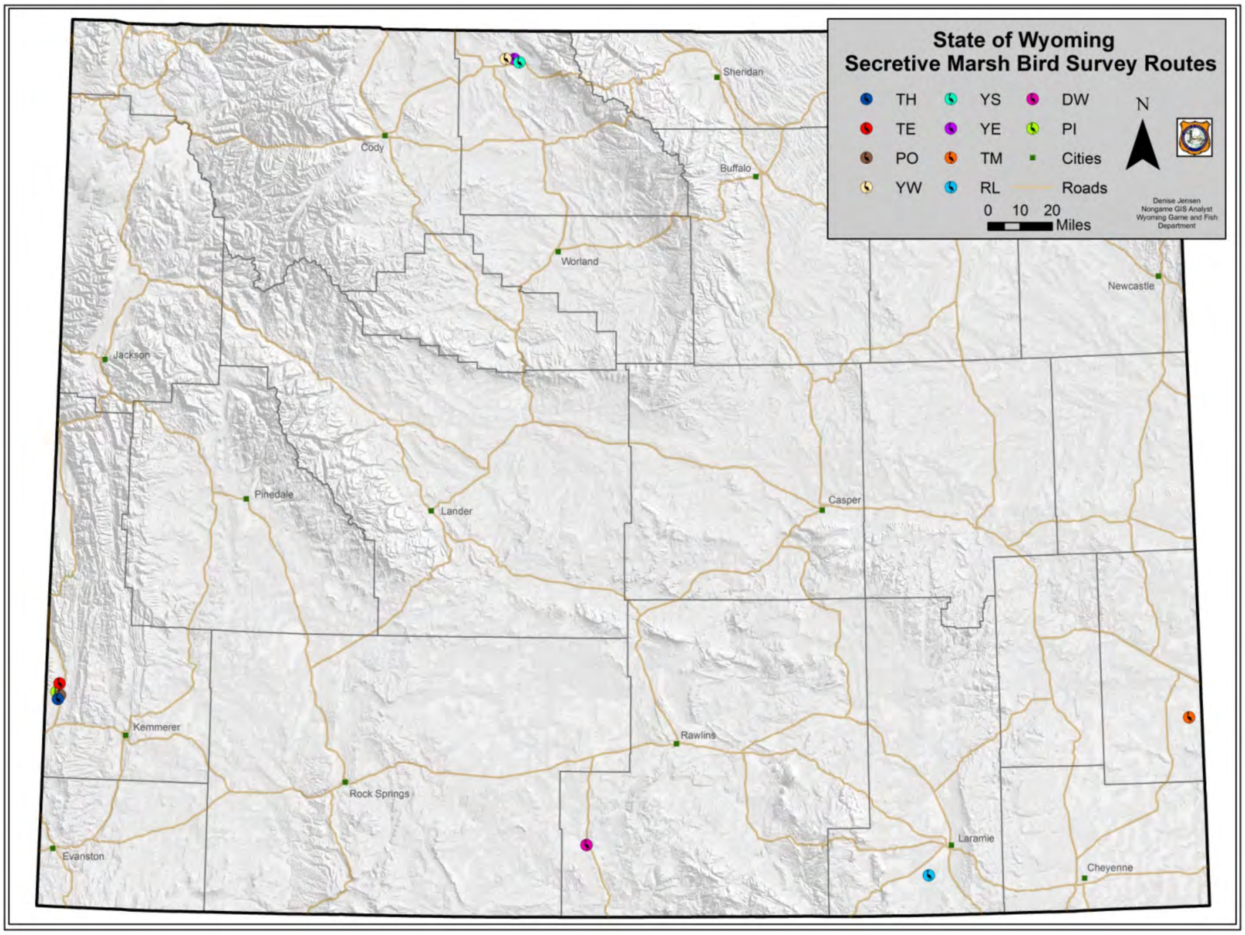

Figure 2. Statewide secretive marsh bird survey route locations we established in 2014 in suitable wetland habitat for implementing the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009). TH = Thornock route, TE = Teichert route, PO = Pope route, YW = Yellowtail West route, YS = Yellowtail South route, YE = Yellowtail East route, TM = Table Mountain route, RL = Rush Lake route, DW = Dad Wetland route, PI = Pixley Route.

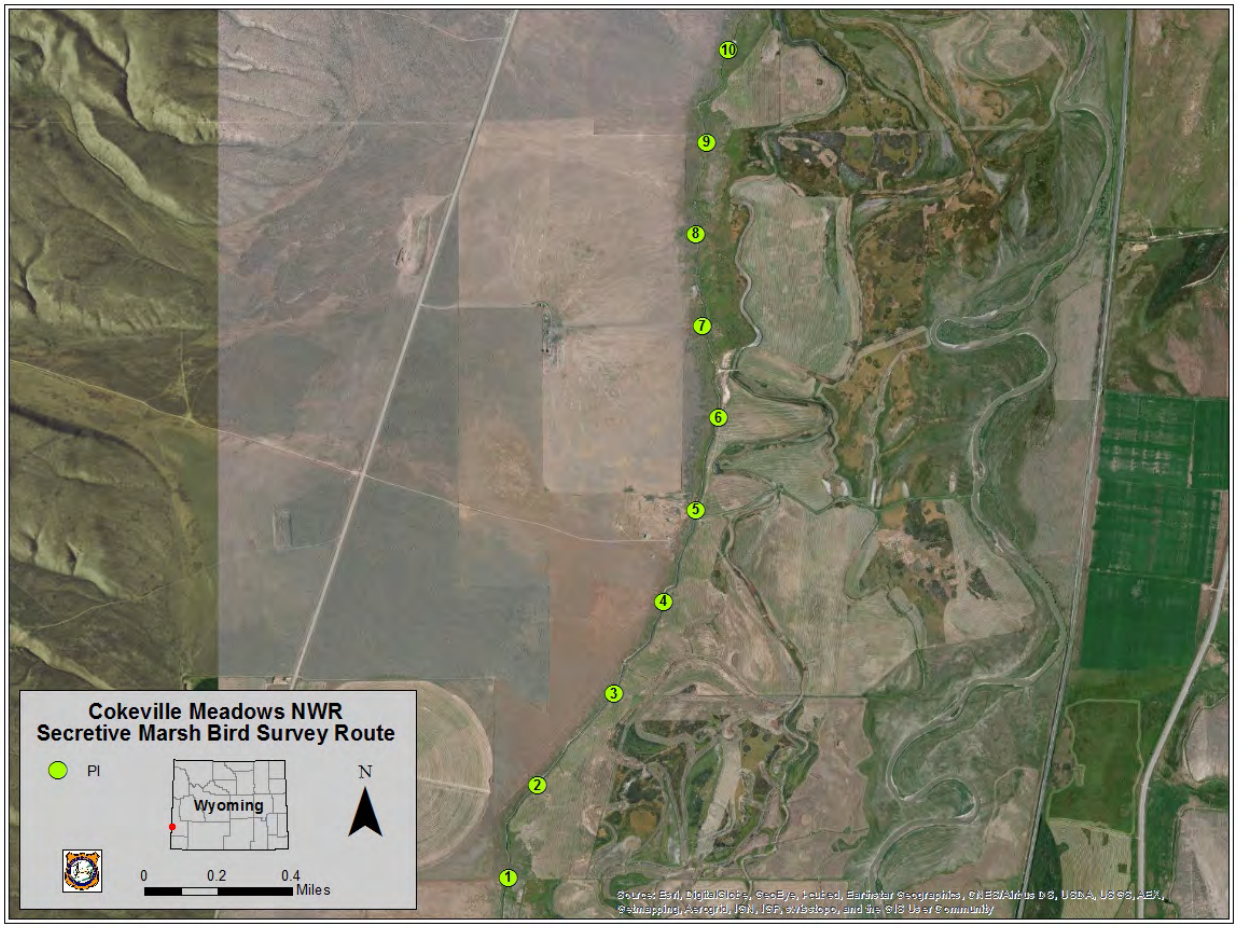

Figure 3. Location of the Pixley secretive marsh bird survey route we established on the Cokeville Meadows National Wildlife Refuge, Wyoming.

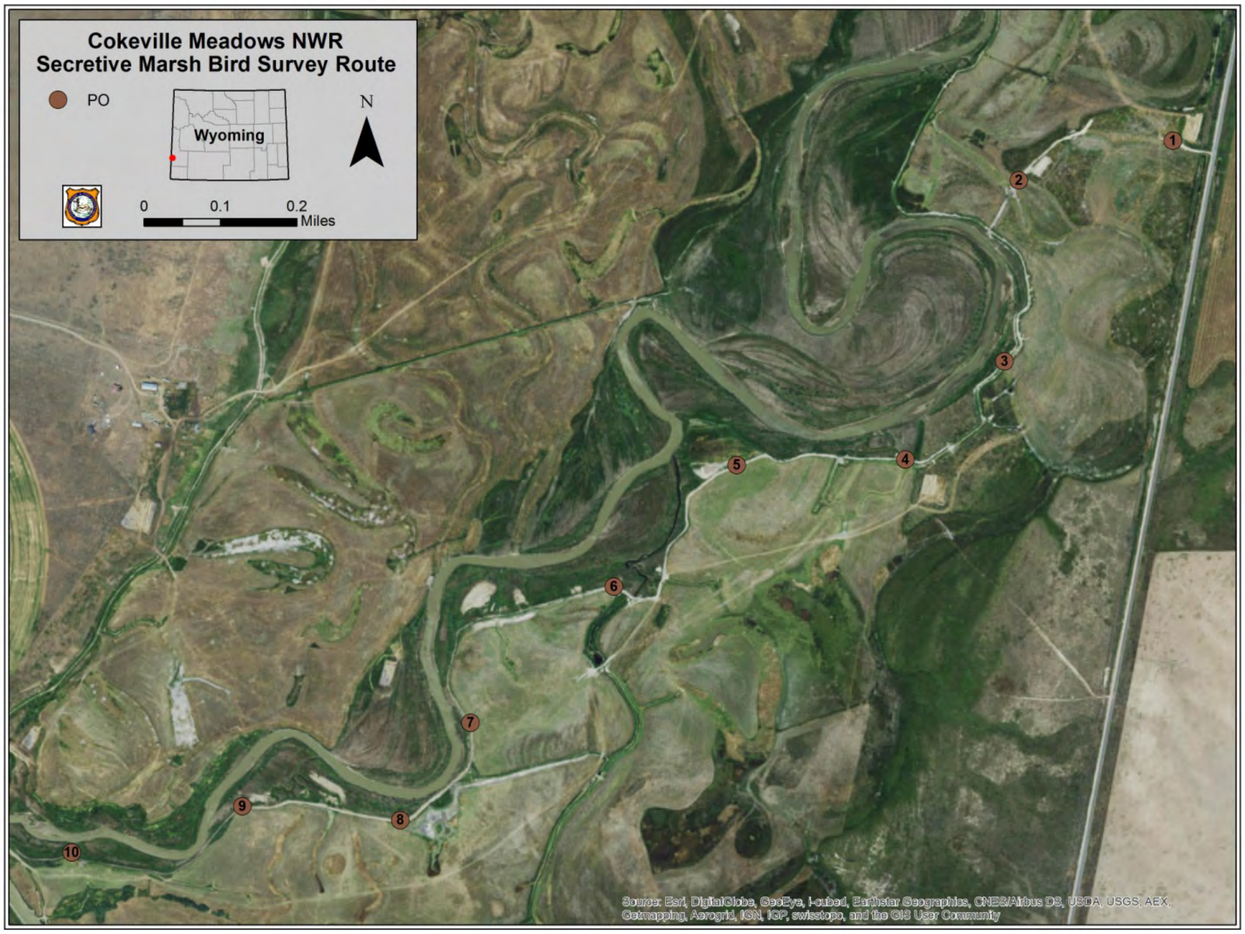

Figure 4. Location of the Pope secretive marsh bird survey route we established near the Cokeville Meadows National Wildlife Refuge, Wyoming.

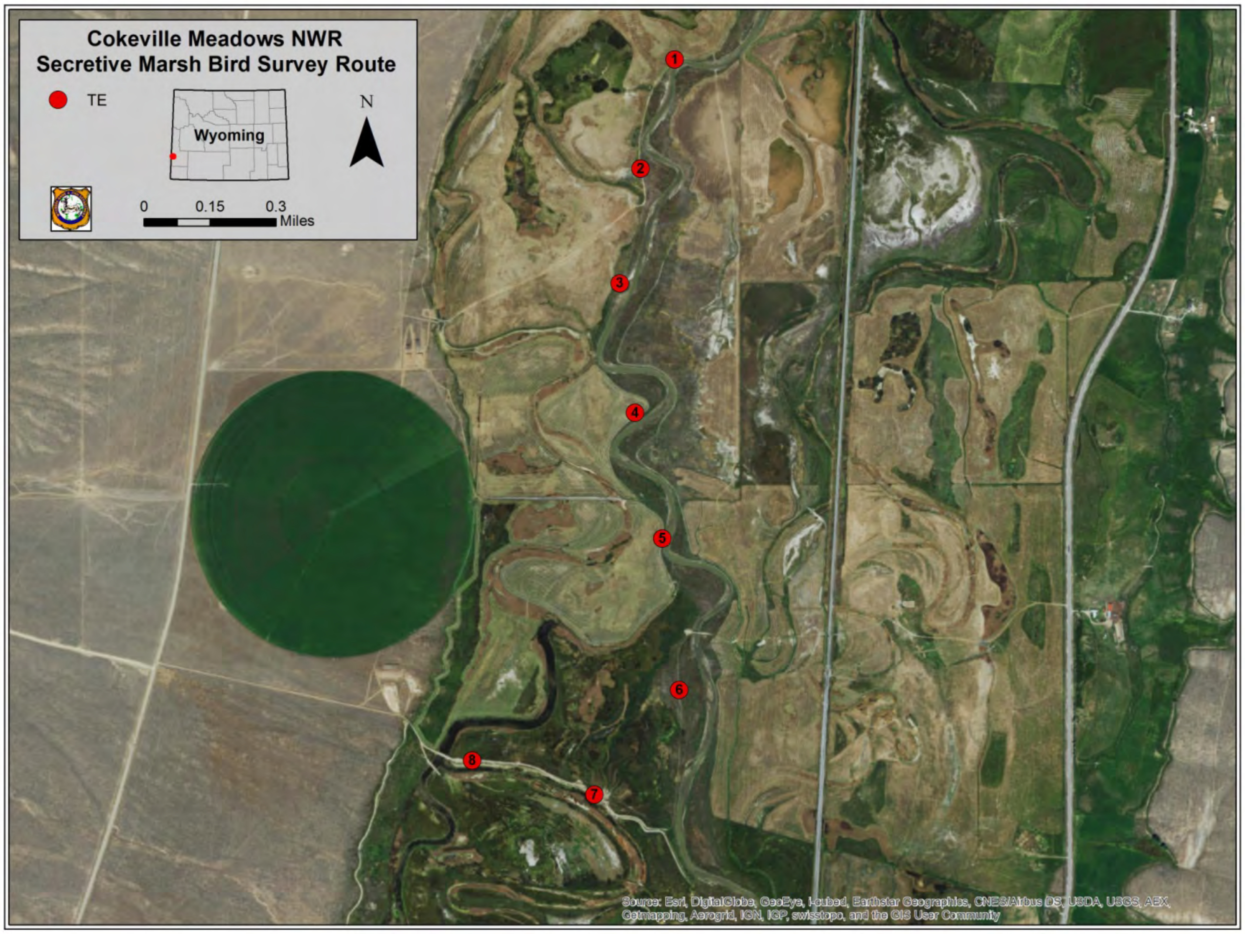

Figure 5. Location of the Teichert secretive marsh bird survey route we established near the Cokeville Meadows National Wildlife Refuge, Wyoming.

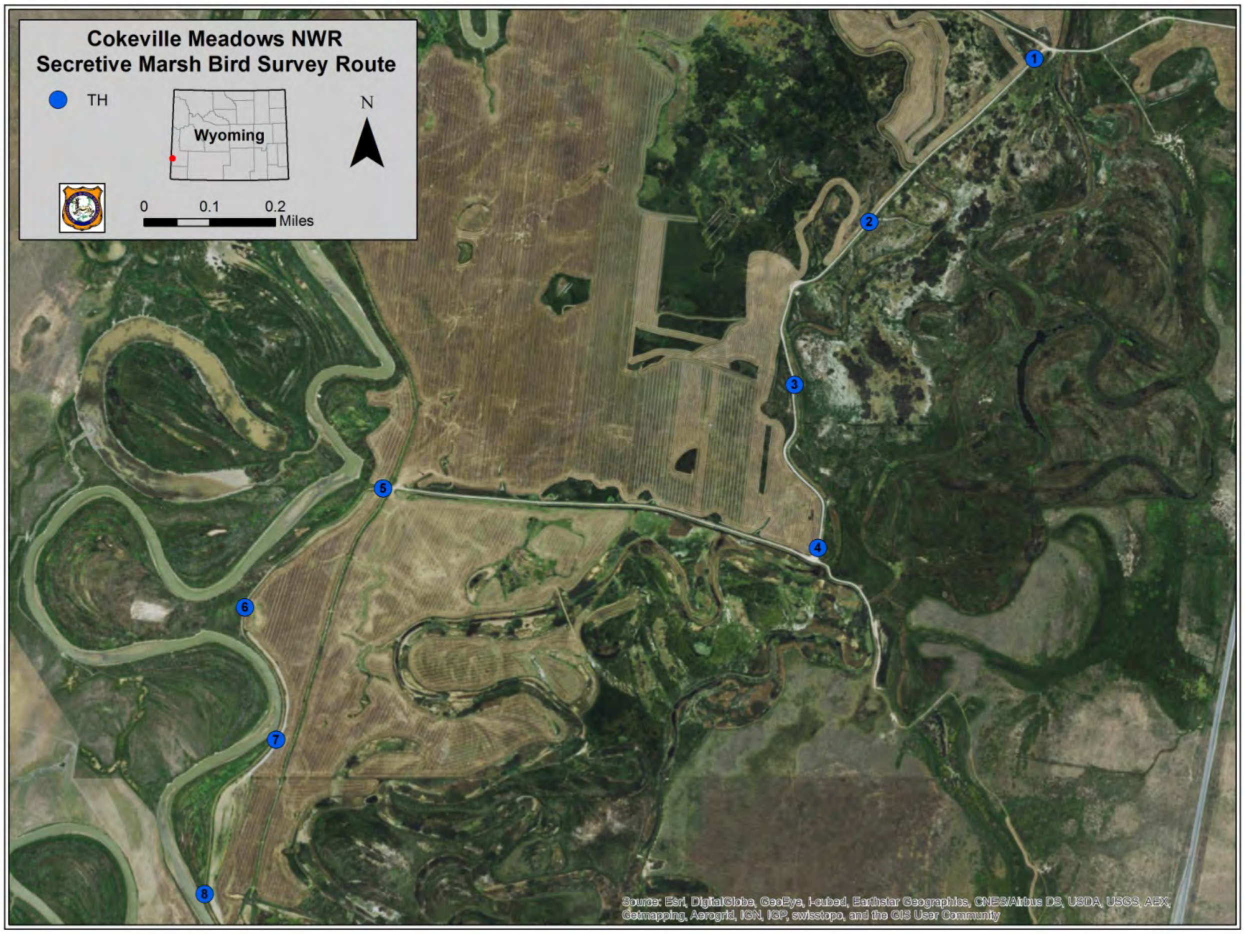

Figure 6. Location of the Thornock secretive marsh bird survey route we established on the Cokeville Meadows National Wildlife Refuge, Wyoming.

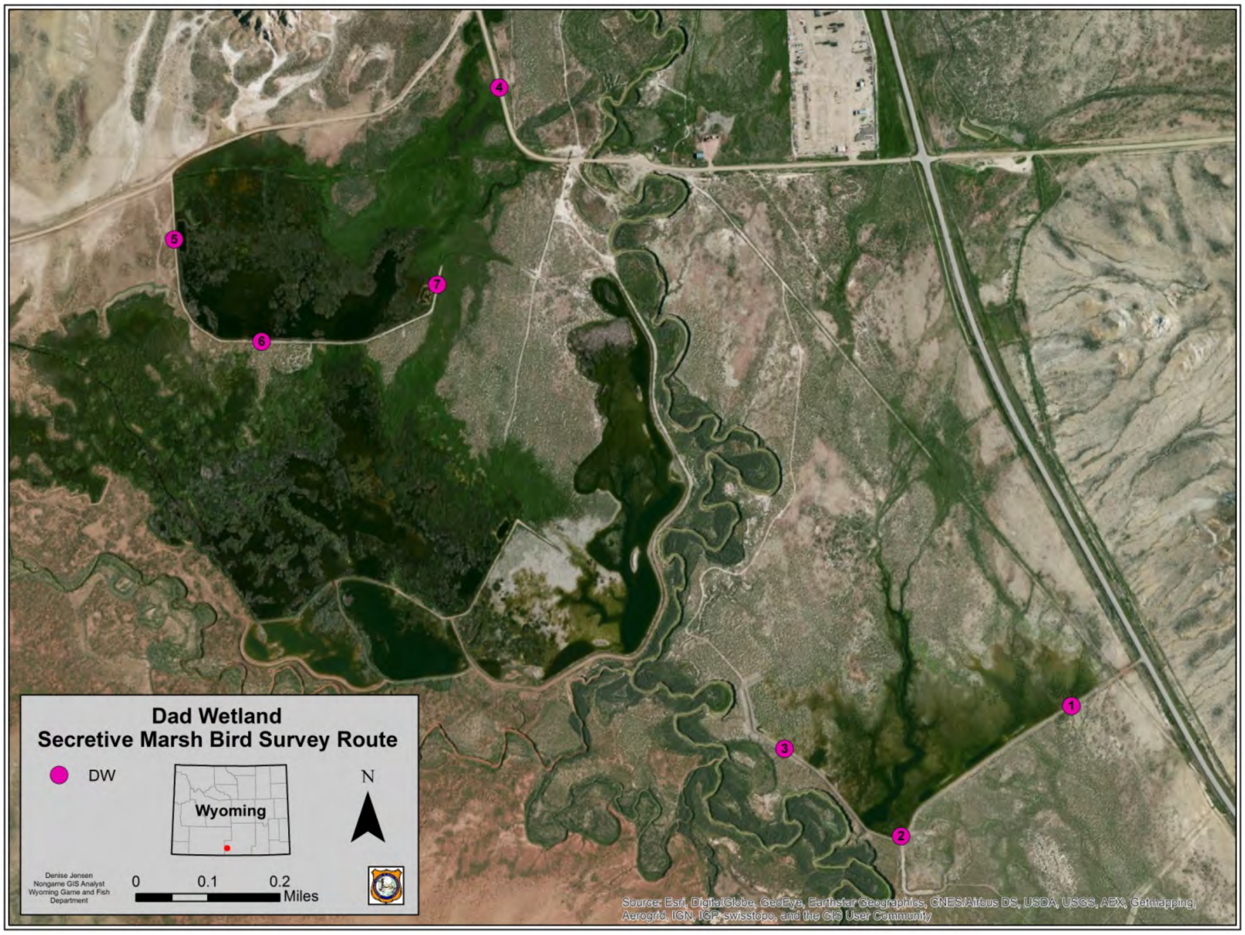

Figure 7. Location of the Dad Wetland secretive marsh bird survey route we established near Baggs, Wyoming.

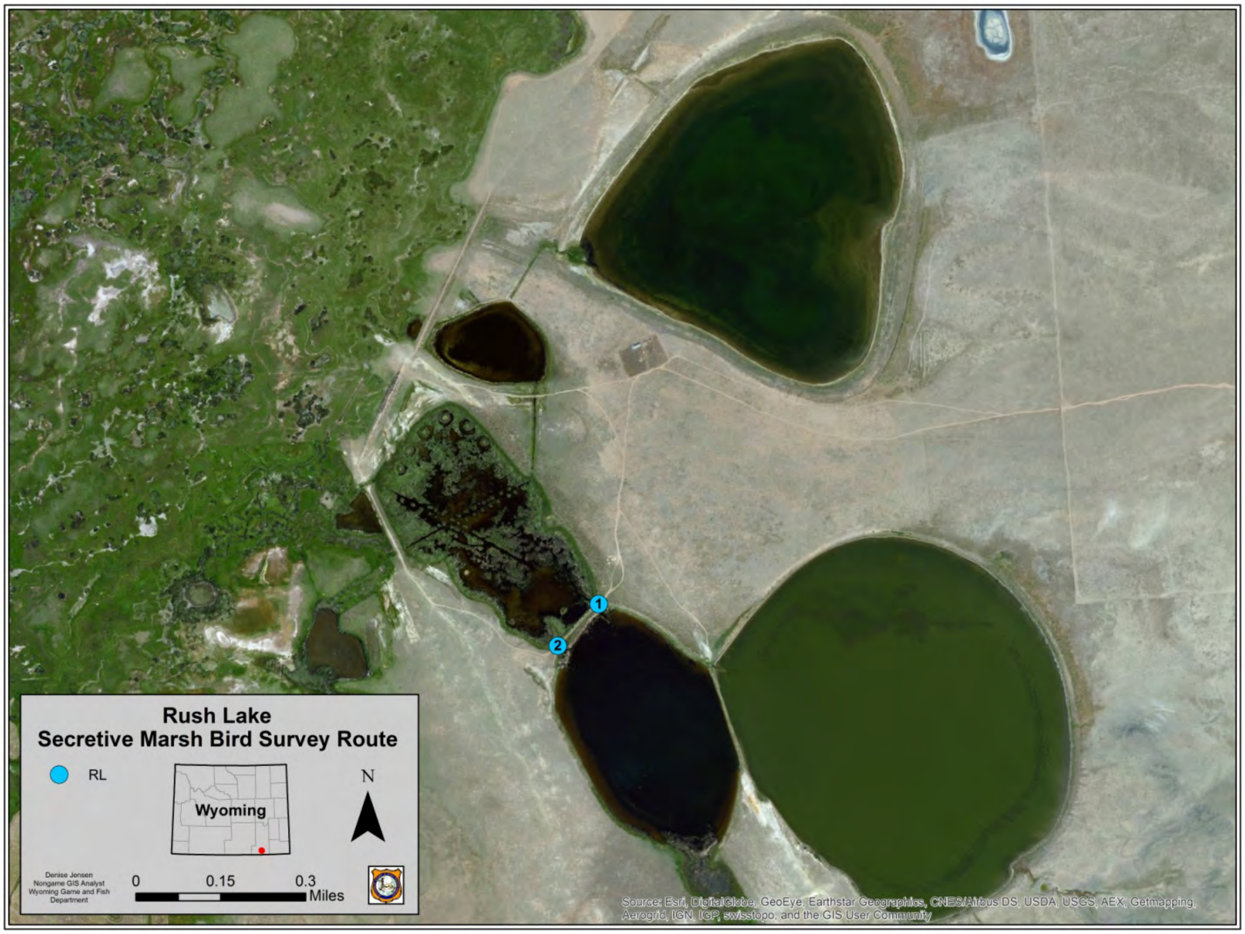

Figure 8. Location of the Rush Lake secretive marsh bird survey route we established on the Hutton Lake National Wildlife Refuge, Wyoming.

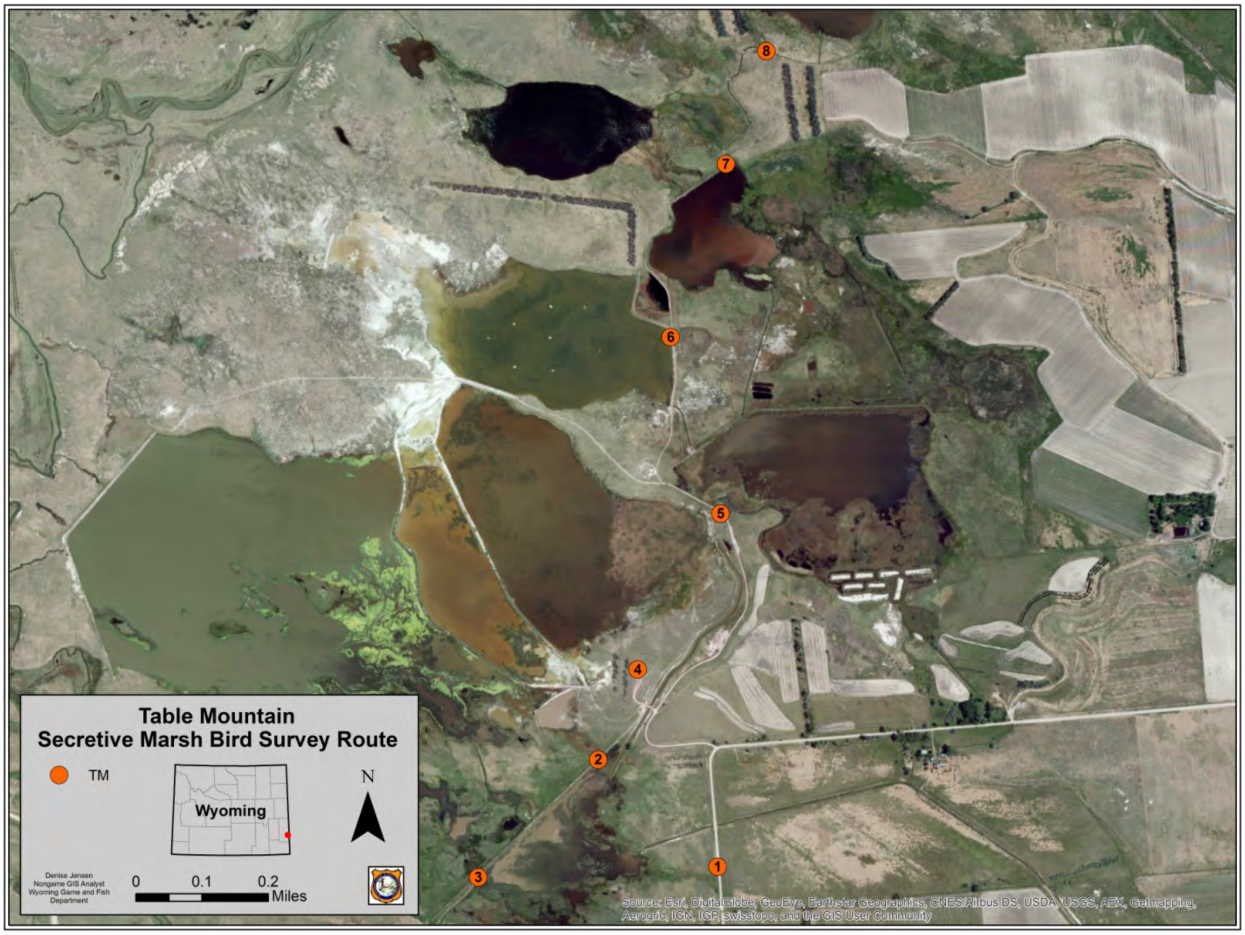

Figure 9. Location of the Table Mountain secretive marsh bird survey route we established on the Table Mountain Wildlife Habitat Management Area, Wyoming.

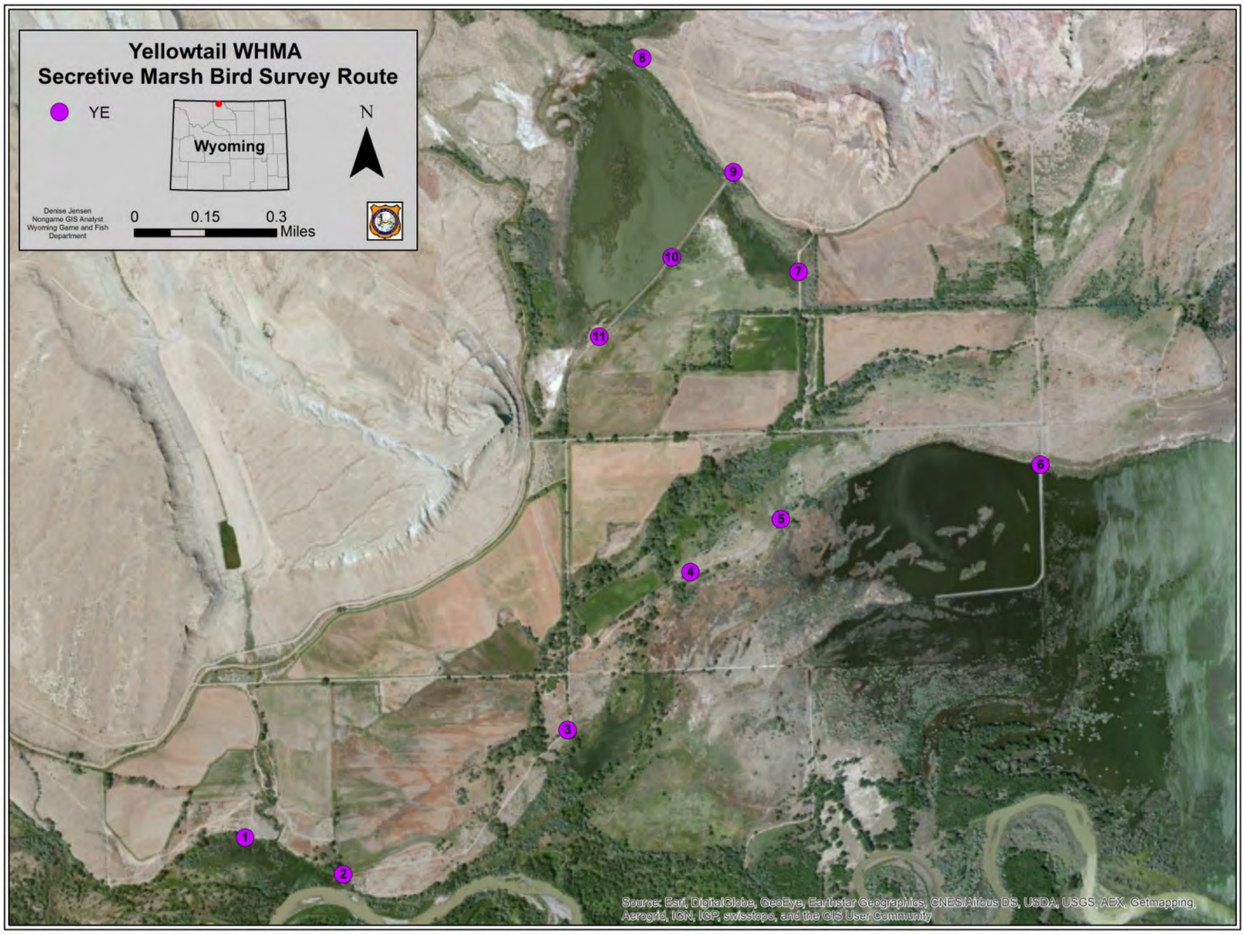

Figure 10. Location of the Yellowtail East secretive marsh bird survey route we established on the Yellowtail Wildlife Habitat Management Area, Wyoming.

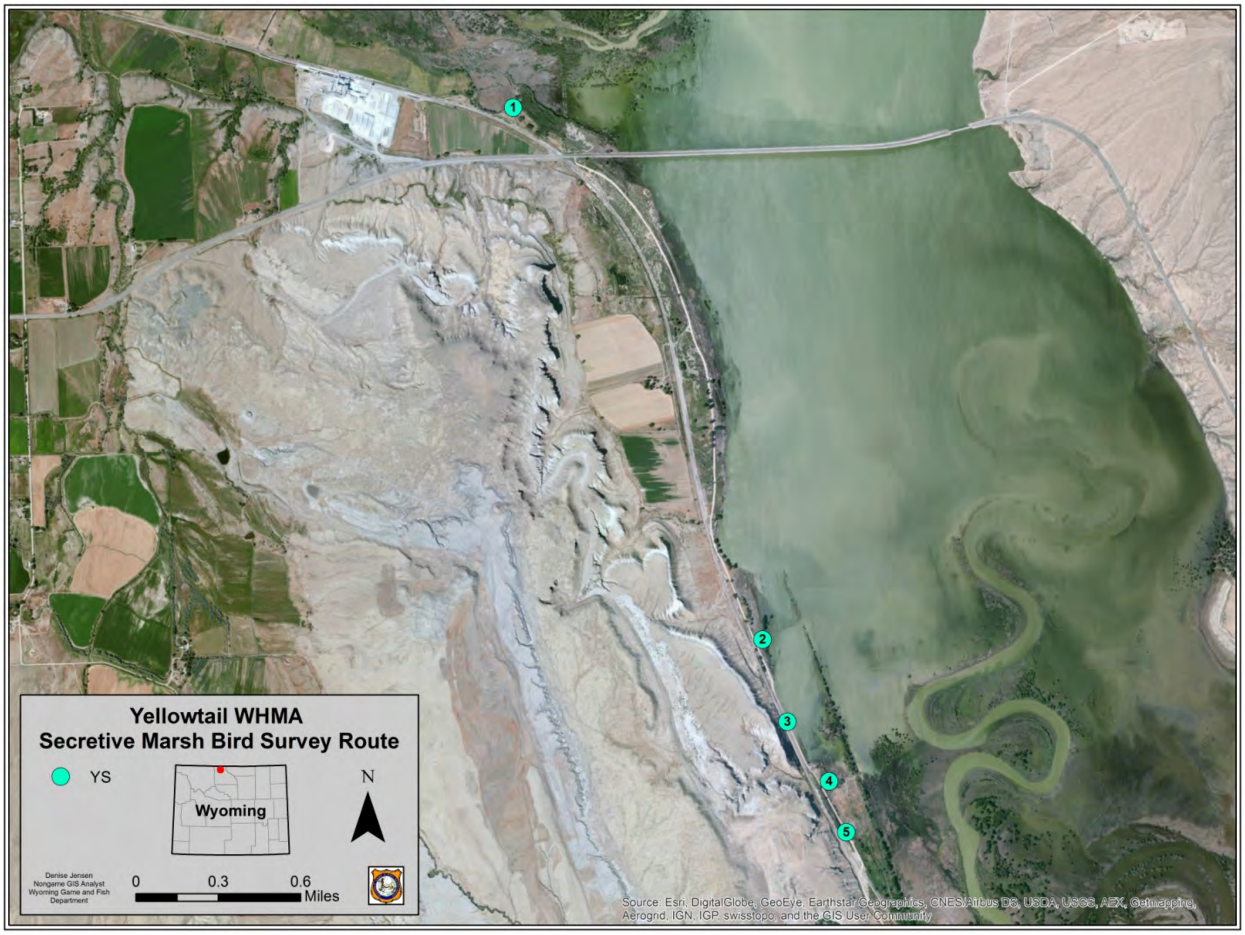

Figure 11. Location of the Yellowtail South secretive marsh bird survey route we established on the Yellowtail Wildlife Habitat Management Area, Wyoming.

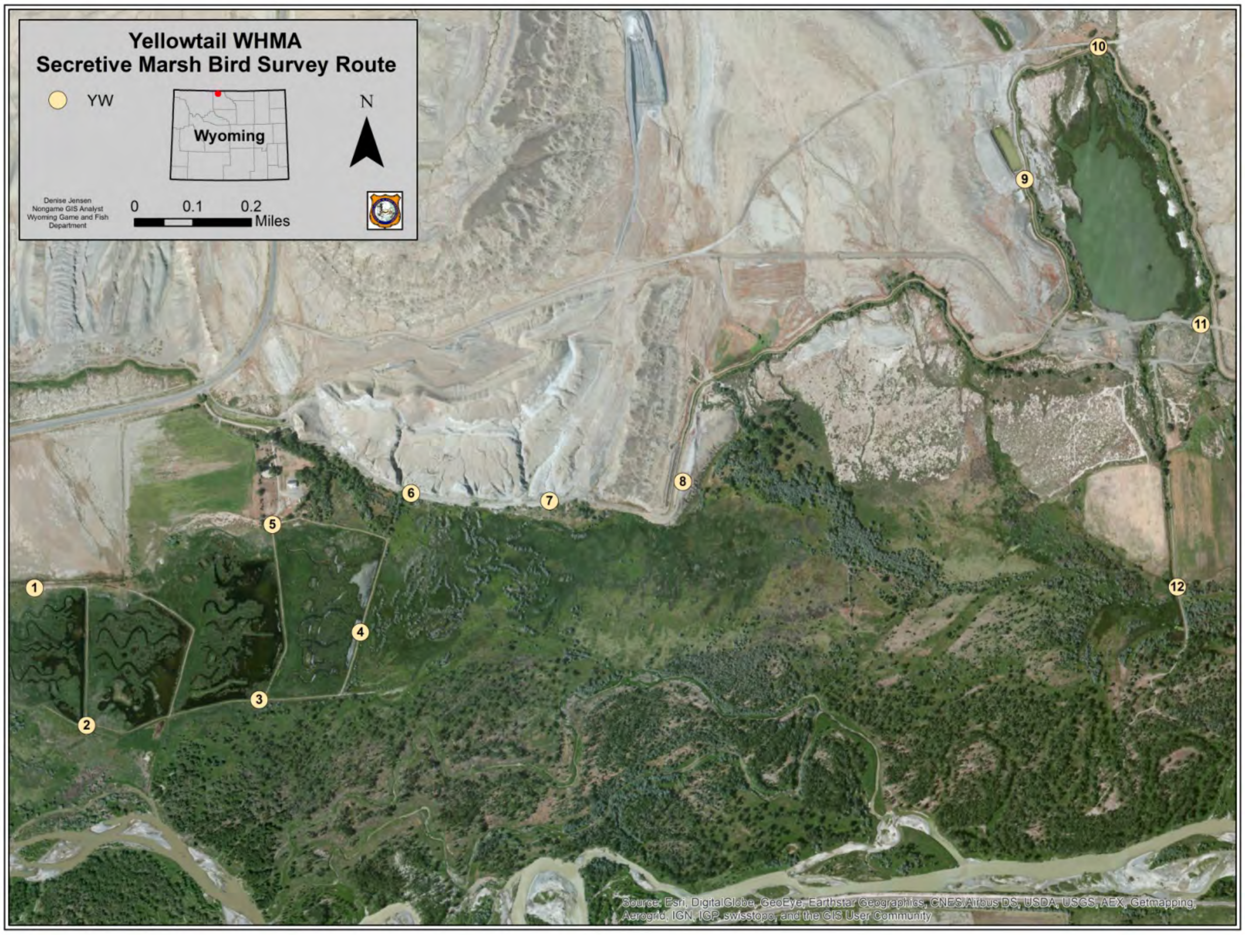

Figure 12. Location of the Yellowtail West secretive marsh bird survey route we established on the Yellowtail Wildlife Habitat Management Area, Wyoming.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) MONITORING IN WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Bald Eagle

FUNDING SOURCE: United States Army Corps of Engineers
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2015 – 1 March 2016

PREPARED BY: Susan Patla, Nongame Biologist

ABSTRACT

The Bald Eagle (*Haliaeetus leucocephalus*) occurs throughout most of North America from Alaska to central Mexico and winters generally throughout the breeding range except in the far north. It nests along major river drainages and lakes throughout Wyoming, with the most significant concentrations in Teton, Sublette, and Carbon Counties, including a significant number of nesting pairs in Grand Teton and Yellowstone National Parks. We initiated monitoring for Bald Eagle statewide in 1978. The Bald Eagle, although no longer designated as a Threatened species under the Endangered Species Act, remains protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act, and is classified as a Species of Greatest Conservation Need with Native Species Status of 2 in Wyoming. We currently monitor the population of Bald Eagles that nest in the western portion of the state (i.e., Snake and Green River drainages) annually, and obtain data when available from other areas of the state. We have detected ≥139 nest sites to-date. However, we believe there is potential habitat for ≥200 territories to occur statewide. In 2015, we obtained occupancy data for 101 territories and productivity data for 67 nest sites. As in previous years, Bald Eagles occupied a high proportion (i.e., ≥83%) of nesting territories we monitored, and successful nests produced an average of 1.6 young per nest. We documented a total of 84 mature young from surveys in western Wyoming. Bald Eagles that nest in Wyoming and continue to show strong productivity still experience some site-specific risks due to increasing energy development, rural development, recreational activities, and environmental contaminants. We continue to receive and process numerous requests for information and management recommendations for Bald Eagle nest and roost sites.

INTRODUCTION

The Bald Eagle (*Haliaeetus leucocephalus*) nests along all major river systems in Wyoming, but the largest number of nesting pairs is found in northwestern Wyoming in the Greater Yellowstone Area (GYA) along the Snake River drainage and its tributaries. Bald Eagles in the northwestern part of the state have long been recognized as part of a distinct population that nests in the Rocky Mountain West. This genetically distinct population extends into Idaho and Montana (Swenson et al. 1986). Recovery of the species in Wyoming centered on the Jackson area beginning in the 1980s. The numerous territories located along the Snake River continue to serve as a source of Bald Eagles for other areas of the GYA and other parts of Wyoming (Harmata and Oakleaf 1992). Since 2000, we have also documented a substantial increase in the number of pairs that nest in the Green River Basin. Bald Eagles that nest in Wyoming continue to experience some site-specific risks from increasing energy development, rural development, recreational activities, and environmental contaminants.

The US Fish and Wildlife Service (USFWS) removed the Bald Eagle from protection under the Endangered Species Act in the western US in July 2007. However, the species continues to be protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Act Treaty. The USFWS released national management guidelines to advise landowners and land managers under what circumstances the protective provisions of BGEPA may apply to activities where eagles occur (USFWS 2007). They have also released guidelines to assist developers of land-based wind energy projects in identifying risks to wildlife species, including Bald Eagles (USFWS 2012). In addition, they have finalized permit regulations that allow for limited take of bald and golden eagles where the take is associated with otherwise lawful activities (USFWS 2009).

The Wyoming Game and Fish Department (Department) initiated monitoring for Bald Eagles statewide in 1978. Currently, program objectives include monitoring occupancy and productivity at nesting territories in the Snake River and Green River Basin, south to Seedskadee National Wildlife Refuge (NWR). Additional surveillance data are collected at a number of other sites around the state by Department personnel. We continue to receive numerous requests by other state and federal agencies and the public for information on status of nests of Bald Eagles, and provide recommendations on mitigation measures to conserve nest sites in Wyoming. The Army Corp of Engineers (ACE) request data every year on the status of nest sites located adjacent to the Snake River dike system in the Jackson area to schedule maintenance projects. The ACE has provided funding support the last few years for aerial survey work. Management guidelines have been developed for nest sites for the GYA based on a long-term ecological study, and provide valuable information for avoiding disturbance to nesting eagles (Greater Yellowstone Bald Eagle Working Group 1996). The Department is actively involved in reviewing new federal regulations through participation in the Central Flyway Nongame Migratory Bird Technical Committee.

METHODS

We conducted aerial surveys to monitor occupancy and productivity at a majority of known Bald Eagle nest sites in western Wyoming. Fixed-wing aircraft surveys were conducted in mid- to late March to document the number of occupied sites with incubating adults, and again in late May and early June to determine number of mature young produced per site. During aerial surveys, we recorded the number of adult and young Bald Eagles observed, UTM coordinates of nests, condition of nests, and species of nest tree, and photographed new sites. We also recorded locations of other Species of Greatest Conservation Need (WGFD 2010).

In 2015, we used a single observer and fixed-wing Scout airplane (Sky Aviation) that flew approximately 100-200 m above ground and at speeds of 120-160 kph to conduct aerial nest occupancy surveys on 30 and 31 March, and a productivity survey on 30 May. We combined the productivity flight for eagles with a monitoring survey for Trumpeter Swan (*Cygnus buccinator*) to reduce overall survey costs. We surveyed all known nest sites along the main stem and tributaries of the Snake River, Gros Ventre River, Salt River, New Fork River, and the Green River from Green River Lakes to south of Seedskadee NWR.

Biologists from Grand Teton National Park, Seedskadee NWR, the Department, and the USFWS contributed data from their respective monitoring efforts. A few volunteers in Jackson also surveyed specific territories on a regular basis. In other parts of the state, Regional Wildlife Biologists collected data for a subset of known nests that were visible from the ground. These data are not included in this report; results can be accessed through the Department's Wildlife Observation System database. For ground-based surveys, observers used spotting scopes or binoculars from observation points that were sufficiently far away to prevent disturbance to nesting Bald Eagles. Survey duration was typically ≤2 hrs depending on visibility, behavior of adult birds, and status of the nest. Some wildlife consultant companies provided nest observation data, as well.

RESULTS

In 2015, we evaluated occupancy status of 83 nest sites. Data collected from nest sites in Yellowstone National Park and by private consultant groups in other parts of Wyoming are not summarized here; consequently, this report represents a minimum count of nesting Bald Eagles that occur statewide. Monitoring effort was concentrated in western Wyoming where the majority of nests are known to occur and where the Department has collected nest site data since the late 1970s.

Bald Eagles occupied 89% of sites surveyed. Table 1 presents productivity data for nest sites in western Wyoming that we monitored consistently through repeated aerial or ground surveys. The majority of occupied nests were found along the main stem of the Snake River (including Jackson Lake) and the Green River drainage (Table 1, Figure 1). Overall, 85% of the territories we checked for productivity in western Wyoming produced mature young. The number of mature young produced per successful nest was 1.42 or 1.09 per occupied nest. Overall, 6 nest sites failed in the Jackson area, half of the number that failed in the previous 2 years, indicating favorable spring nesting conditions. We documented only one nest failure in the Green River nesting cohort. No emergency dike work was required in 2015 by the ACE along the Snake River dike system. A project to remove vegetation along the Snake River dikes continued along the river south of Wilson. The FWS issued 1 take permit for a construction project in the Crescent H subdivision south of Wilson.

DISCUSSION

The number of nesting pairs of Bald Eagles appears to have stabilized in the Snake River drainage in Wyoming, with some shift in pairs occurring over time but few new territories being discovered. New nests continue to be found in the Green River drainage. In 2015, a nesting pair was documented near the confluence of the Green and New Fork Rivers in Sublette County. Comparing productivity data for the Greater Yellowstone population collected from 1982-1995 to the current year indicates that current productivity, or the number young produced per occupied site, for 2015 is within the historic range (Greater Yellowstone Bald Eagle Working Group 1996).

The Department provides data on nesting eagles for numerous requests every year from county, state, and federal agencies and private consultants for use in evaluating proposed projects and developing mitigation measures to protect nesting territories. In the future, additional surveys may be needed in areas where energy developments (i.e., oil, gas, and wind) occur or are proposed along major drainages or known migration routes and wintering areas. We hypothesize that in areas undergoing high levels of development along major river corridors, Bald Eagles could experience higher mortality rates, lower productivity, or loss of nest sites if adequate mitigation measures are not applied. Aging stands of cottonwood trees that are failing to regenerate may also reduce nesting habitat in some areas in future years.

ACKNOWLEDGEMENTS

We greatly appreciate the efforts of the following individuals for providing data on nesting Bald Eagles in 2014: D. Patla (volunteer); B. Bedrosian (Teton Raptor Center); E. Cole (National Elk Refuge); T. Koerner (Seedskadee NWR); J. Stephenson, S. Hegg, J. Schwabedissen, and P. Andrews, (Grand Teton National Park); and B. Jones (Teton County). We greatly appreciate funding provided by the Wyoming State Legislature General Fund Appropriations, as well as the ACE (Walla Walla office) for aerial surveys.

LITERATURE CITED

Greater Yellowstone Bald Eagle Working Group. 1996. Greater Yellowstone Bald Eagle management plan: 1995 update. Greater Yellowstone Bald Eagle Working Group, Wyoming Game and Fish Department, Lander, USA.

Harmata, A., and B. Oakleaf. 1992. Bald Eagles in the Greater Yellowstone Ecosystem: an ecological study with emphasis on the Snake River, Wyoming. Wyoming Game and Fish Department, Cheyenne, USA.

Swenson, J. E., K. A. Alt, and R .L. Eng. 1986. Ecology of Bald Eagles in the Greater Yellowstone Ecosystem. Wildlife Monographs 95:1-46.

United States Fish and Wildlife Service [USFWS]. 2007. National Bald Eagle Management Guidelines. US Fish and Wildlife Service, Washington, D.C., USA. http://www.fws.gov/northeast/ecologicalservices/pdf/NationalBaldEagleManagementGuidelines.pdf (accessed 1 March 2016).

United States Fish and Wildlife Service [USFWS]. 2009. Eagle Permits; Take Necessary to Protect Interests in Particular Localities. Federal Register, Volume 74, Number 175, 50 CFR, Parts 13 and 22. www.fws.gov/northeast/EcologicalServices/pdf/FinalDisturbanceRule9Sept2009.pdf (accessed 1 March 2016).

United States Fish and Wildlife Service [USFWS]. 2012. Land-based wind energy guidelines. OMB Control Number 1018-0148. US Fish and Wildlife Service, Washington, D.C., USA. http://www.fws.gov/ecological-services/es-library/pdfs/WEG_final.pdf (accessed 1 March 2016).

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Summary of Bald Eagle (*Haliaeetus leucocephalus*) nesting data collected by the Wyoming Game and Fish Department Nongame Program in 2015. We present data by major drainages and geographic boundaries in Wyoming. [a] Greater Yellowstone Area (GYA) does not include data for 3 pairs in Lincoln County (Salt River) or data from Yellowstone National Park. [b] Aerial surveys from Green River Lakes to Fontenelle Dam; ground surveys on the Seedskadee National Wildlife Refuge. [c] Data only received from the Casper region. [d] Percentage of occupied territories checked for productivity that produced mature young. [e] Mature young is the number of fully feathered nestlings counted prior to fledging in June and July. nc = not counted.

Nesting data collected	Wyoming portion of GYA[a]	Green River[b]	Bear River	Salt River	Western Wyoming total
Territories checked for occupancy (*n*)	50	31	nc	2	83
Territories occupied (*n*)	42	30	nc	2	74
Percent of territories occupied	84%	90%		100%	89%
Territories surveyed for productivity (*n*)	39	26		2	67
Territories that produced young (*n*)	29	26		2	57
Percent of successful nests[d]	74%	100%		100%	85%
Mature young produced[e] (*n*)	42	37		2	81
Mature young per successful nest ($\bar{x}$)	1.45	1.42		1.0	1.42

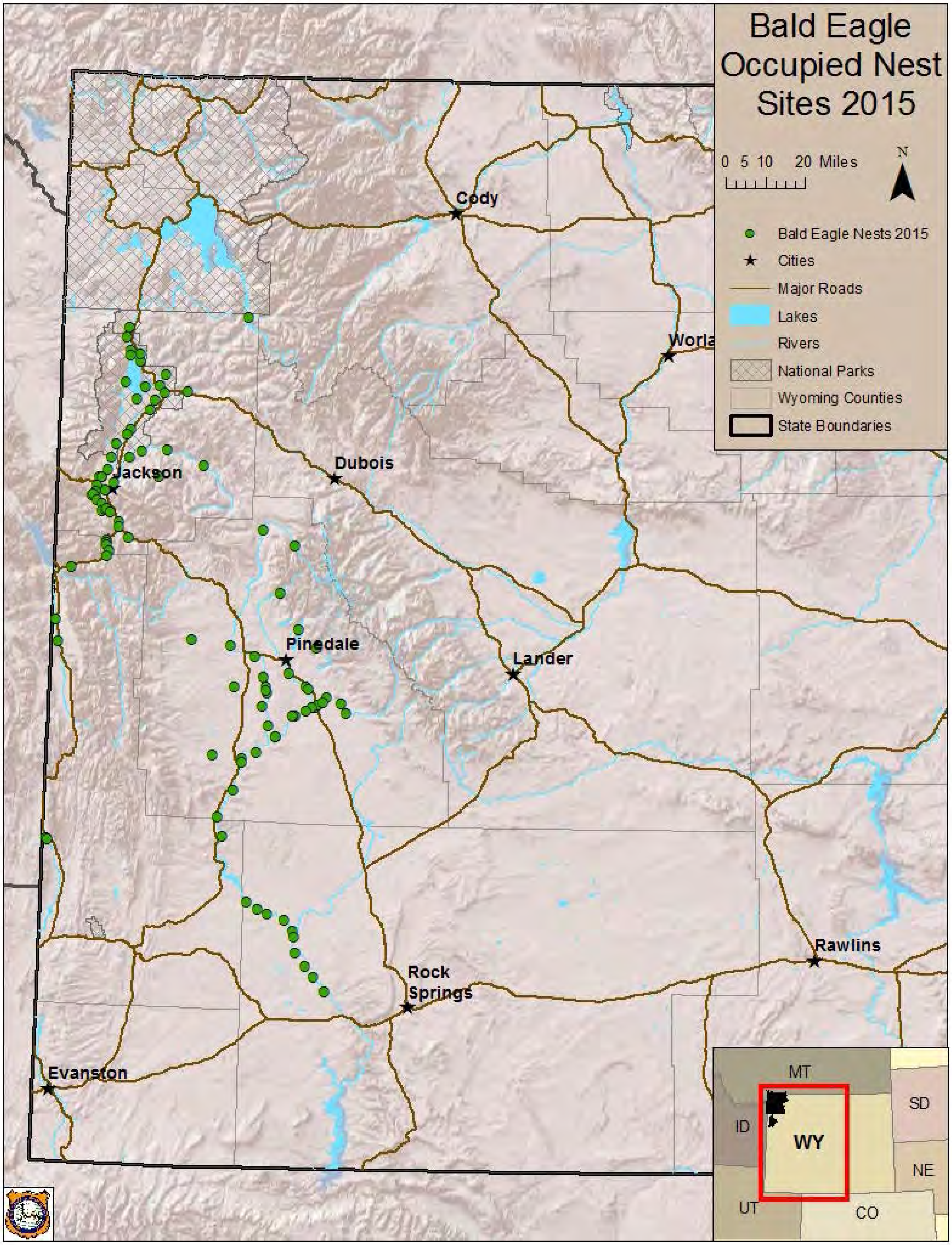

Figure 1. Map of Bald Eagle (*Haliaeetus leucocephalus*) nest sites occupied by nesting pairs that were monitored by the Wyoming Game and Fish Department and partners in western Wyoming in 2015. Occupied nest sites in Yellowstone National Park are not shown.

PRODUCTIVITY OF PEREGRINE FALCONS (*FALCO PEREGRINUS*) IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Peregrine Falcon

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
United States Fish and Wildlife Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2015– 14 April 2016

PREPARED BY: Bob Oakleaf, Nongame Program Technician
Susan Patla, Nongame Biologist
Doug Smith, Senior Wildlife Biologist, Yellowstone National Park

ABSTRACT

We have continued to monitor nesting Peregrine Falcons (*Falco peregrinus*) in Wyoming since the species was removed from protection under the federal Endangered Species Act in 1999. In cooperation with the US Fish and Wildlife Service, Wyoming participated in the National Monitoring Plan for delisting of the American Peregrine Falcon every 3 years (2003, 2006, 2009, 2012, and 2015). We have also monitored nesting performance of Peregrine Falcons at additional sites in Wyoming on an annual basis between US Fish and Wildlife Service-sponsored surveys. In 2015, we found 35 of 38 (92%) nesting territories occupied, which fledged 35 young or 1.0 young per occupied site. Results in 2015 indicate lower production than in previous years. However, long-term averages remain well above recovery goals, indicating that the Peregrine Falcon nesting population is stable in Wyoming.

INTRODUCTION

In cooperation with The Peregrine Fund, Inc., the Wyoming Game and Fish Department (Department) developed plans from 1978-1980 to re-establish Peregrine Falcons (*Falco peregrinus*; peregrine) in Wyoming based on analysis of historical distribution and evaluation of potential habitat during survey work. Our goal of reintroduction was to establish and maintain a self-sustaining breeding nucleus in the wild. We set objectives to annually release approximately 15 peregrines and establish 30 breeding pairs in Wyoming by 1996. We coordinated the program with the US Fish and Wildlife Service (USFWS), National Park Service, the US Forest Service, Bureau of Land Management, and state wildlife agencies in Idaho and Montana to ensure maximum results to re-establish this species. Peregrine reintroduction and monitoring efforts are detailed in previous Department Nongame Annual Completion Reports and annual reports completed by The Peregrine Fund, Inc. In Wyoming, we released 384 peregrines from 1980-1995, with ≥325 (85%) surviving to dispersal (i.e., 1 month post-release). We have not released peregrines since 1995 because we attained project objectives in 1994-1995, and the species was subsequently delisted at the national level in 1999. We do, however, continue monitoring efforts, as populations are relatively limited. In cooperation with the USFWS and using USFWS supplemental funding, Wyoming has conducted surveys every 3 years (2003, 2006, 2009, 2012, and 2015; Table 1). We have also monitored nesting performance of peregrines in Wyoming on an annual basis between these USFWS-sponsored surveys.

METHODS

We recorded potential peregrine nesting cliffs in Wyoming during baseline surveys from 1978-1980, and periodically checked them for occupancy during ground surveys. We collected data on occupancy and fledging from as many of the known peregrine territories as possible from 1984-2004. Since 2005, we have randomly selected 30 territories per year to survey. Ten territories were randomly selected annually for each of 3 areas: Yellowstone National Park, west of the continental divide outside of Yellowstone National Park, and the rest of Wyoming east of the continental divide. During the years of the USFWS National Monitoring Plan, 15 previously selected territories were automatically selected, and an additional 15 were randomly chosen so that we attempt to annually monitor ≥30 territories. We included additional territories that we observed, as time allowed, during travels to selected territories and sites observed by cooperators with interest in specific territories. We present data separately for random sites, additional sites, and all monitored sites combined.

We determined occupancy for each of the selected territories during early season visits and recorded productivity during ≥1 observations of adults feeding young later in the season. Territories where we failed to locate a breeding pair (i.e., not occupied) were selected for repeated visits. These included ≥2 visits each of ≥4 hours before the territory could be classified as not occupied. We determined nest success by ≥2 visits with the last visit timed to observe young ≥28 days old. We often revisited eyries after the young were fledged to assure a more complete count, especially eyries that were situated where it was difficult to observe young that had not fledged.

RESULTS AND DISCUSSION

No nesting pairs of peregrines were located in Wyoming during surveys from 1978-1983. The first nesting pair was documented in 1984, and by 2015 we have documented at least 121 nesting territories in Wyoming. Monitoring of 15 sites selected by the USFWS documented that at least 13 of these sites were annually occupied during a specific breeding season since 2003. However, the number of young fledged per occupied USFWS site has decreased from 1.9 to 0.9 young. In 2015, we surveyed 28 randomly selected nesting territories (including the 15 USFWS sites) to document reproductive performance. Twenty-six (93%) of these random territories were occupied and fledged 30 young, for an average of 1.2 young per occupied territory (Table

2). We also surveyed for occupancy and productivity at an additional 10 nesting territories in 2015, for a statewide total of 38 territories. Thirty-five (92%) of these territories were occupied by breeding adults (Table 3). These 35 occupied territories fledged 35 young, or 1.0 young per occupied territory. When we added survey data from 2015 to cumulative data collected since 1984, we have monitored ≥1,057 nesting attempts at 98 different territories. These nesting attempts resulted in ≥1,581 young, or a mean of 1.5 young fledged per nesting attempt.

While the number of young fledged in 2015 was lower than previous years in all 3 data sets compiled, long term averages indicate that there is a stable Peregrine Falcon breeding population in Wyoming, and peregrines in Wyoming are well above recovery objectives. Normal occupancy rates (92-93%) but low fledging (0.9-1.2 young per occupied site) were apparently the result of extreme and persistent inclement weather during and shortly after hatch in May.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature through General Fund Appropriations and a Cooperative Agreement with the US Fish and Wildlife Service, for which we are extremely grateful. Yellowstone National Park personnel conducted monitoring in Yellowstone, and included L. Baril, D. Haines, B. Cassidy, L. Strait, S. Near, S. Rebinski, K. Duffy, W. Martyn, B. Thorpe, and K. Thorpe. Survey crews in Grand Teton National Park included S. Hegg, J. Schwabedissen, W. Scherer, and J. Stephenson.

Table 1. Peregrine Falcon (*Falco peregrinus*) productivity in Wyoming at National Survey Sites established by the US Fish and Wildlife Service. Percent of successful territories are the number of territories that produced young to fledging divided by the total number of occupied territories.

Year	No. territories monitored	No. territories occupied	No. successful territories (%)	No. young fledged	No. young per occupied territory
2003	15	15	12 (80)	28	1.9
2006	14	14	11 (79)	26	1.9
2009	15	14	7 (50)	14	1.0
2012	14	13	6 (43)	13	0.9
2015	15	14	6 (43)	13	0.9

Table 2. Peregrine Falcon *(Falco peregrinus)* productivity of 30 randomly selected sites in Wyoming, 2005-2014. Percent of successful territories are the number of territories that produced young to fledging divided by the total number of occupied territories.

Year	**No. territories checked**	**No. territories occupied**	**No. successful territories (%)**	**No. young fledged**	**No. young per occupied territory**
2005	30	30	21 (70)	51	1.7
2006	30	30	22 (73)	49	1.6
2007	30	27	19 (70)	40	1.5
2008	22	22	13 (59)	30	1.4
2009	30	25	15 (60)	36	1.4
2010	28	24	19 (79)	42	1.7
2011	24	21	14 (68)	33	1.6
2012	29	23	15 (65)	37	1.6
2013	27	21	14 (67)	30	1.4
2014	29	26	21 (81)	47	1.8
2015	28	26	13 (50)	30	1.2
Mean	27.9	25	16.9 (67.5)	38.6	1.5

Table 3. Peregrine Falcon *(Falco peregrinus)* productivity for all monitored sites in Wyoming, 1998-2013. Percent of successful territories are the number of territories that produced young to fledging divided by the total number of occupied territories.

Year	No. territories checked	No. territories occupied (%)	No. successful territories (%)	No. young fledged	No. young per occupied territory
2005	64	64 (100)	45 (70)	99	1.6
2006	61	61 (100)	44 (72)	101	1.7
2007	54	51 (94)	36 (71)	75	1.5
2008	29	29 (100)	19 (65)	45	1.5
2009	46	41 (89)	28 (68)	58	1.4
2010	42	36 (86)	30 (83)	66	1.8
2011	39	33 (85)	26 (79)	50	1.5
2012	45	38 (84)	25 (66)	61	1.6
2013	43	36 (84)	24 (67)	51	1.4
2014	40	38 (95)	29(76)	65	1.7
2015	38	35 (92)	16 (47)	35	1.0
Mean	45.5	42((92)	29.3 (64)	64.2	1.5

LONG-TERM MONITORING OF AVIAN GRASSLAND SPECIES OF GREATEST CONSERVATION NEED IN WYOMING: SUMMARY OF YEAR 1 RESULTS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Mountain Plover, Upland Sandpiper, Long-billed Curlew, and Burrowing Owl

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 1 April 2015 – 31 August 2015

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

SUMMARY

Grasslands are known to be among the most biologically productive of all plant communities (Williams and Diebel 1996). Their exceptional productivity is a result of a high retention of nutrients, efficient biological recycling, and a structure that provides for an immense assemblage of animal and plant life (Estes et al. 1982). Of the 435 avian species that breed in the US, 330 are known to breed within the 1.3 million km^2 that comprise the Great Plains (Knopf and Samson 1995). Of those 330 species, 12 are endemic to the grasslands; an additional 25 species evolved on the grasslands, even though they may also range widely into adjoining habitat types such as sagebrush, shrubsteppe, and wetlands (Mengel 1970; Table 1; Fig. 1). All 9 of the avian species deemed narrow endemics to the northern Great Plains grasslands occur in Wyoming (Knopf 1996; Table 1). Furthermore, 9 of the 12 grassland endemic species and 15 of the 20 secondary grassland-specific species are regularly occurring breeders in Wyoming (Table 1). The majority of bird species endemic to the shortgrass and mixed-grass prairies are associated with large grazing animals such as bison, while other species such as the Ferruginous Hawk (*Buteo regalis*), Prairie Falcon (*Falco mexicanus*), and Burrowing Owl (*Athene cunicularia*) are either somewhat or strongly associated with the presence of prairie dog colonies on the landscape (Knopf and Samson 1997).

Land conversions from native prairie to agricultural uses, habitat loss and fragmentation, industrialization including wind energy development and natural resources extraction, the introduction and spread of invasive and noxious plants, urbanization, fire suppression, wetland draining, and the removal of native grazers have transformed the grasslands of the Great Plains into one of the most imperiled ecosystems in North America (Knopf 1996, Samson et al. 1998; Fellows and Jones 2009). As a group, grassland birds have shown steeper, more consistent, and

more widespread declines than any other guild of species in North America (Knopf 1992, 1994, 1996).

In 2003, Wyoming Partners in Flight presented information, issues, and recommendations for priority species in the Wyoming Bird Conservation Plan, Version 2.0 (Nicholoff 2003). Recommendations included dedicated monitoring for priority species. In 2006, Wyoming Game and Fish Department (Department) Nongame Program personnel developed A Plan for Bird and Mammal Species of Greatest Conservation Need in Eastern Wyoming Grasslands (Grassland Plan) that identified habitat and species issues and presented objectives to address these concerns (WGFD 2006). The objectives included maintaining inventory and monitoring programs for wildlife populations, working toward removing species from Species of Greatest Conservation Need (SGCN) classification, and working cooperatively with landowners to achieve common goals. The Wyoming State Wildlife Action Plan (SWAP) further identifies problems, conservation actions, and monitoring and research needs for all SGCN (WGFD 2010). Two grassland endemics—Mountain Plover (*Charadrius montanus*) and Long-billed Curlew (*Numenius americanus*)—and two secondary grassland associates—Upland Sandpiper (*Bartramia longicauda*) and Burrowing Owl—are classified as SGCN in the SWAP (WGFD 2010; Table 1).

Although objectives, inventories, and conservation actions were initially being addressed by the Department's Landowner Incentive Program Coordinator, this position was vacated and is no longer available, leaving a gap in the grassland SGCN monitoring program and a limited ability to adequately address management and conservation of these SGCN. With a probable increase in industrialization in Wyoming and associated habitat modifications, the need to fill these data gaps is of critical importance. This will enable us to determine population parameters of these species, identify risks and concerns, and apply timely actions to address issues and avoid potential listings under the federal Endangered Species Act (ESA).

This project addresses 4 avian SGCN, 3 of which are classified as Native Species Status Unknown (NSSU; WGFD 2010) and will benefit greatly from a dedicated monitoring program. Current long-term monitoring programs (i.e., Breeding Bird Survey and Integrated Monitoring in Bird Conservation Regions) adequately monitor numerous species of birds in Wyoming, but do not sufficiently quantify population parameters for these 4 grassland species due to the seasonal timing during which the surveys are conducted and/or the survey techniques used.

The Mountain Plover is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSSU, Tier I classification in the SWAP (WGFD 2010). A narrow range of habitat requirements combined with a high degree of site fidelity and susceptibility to disturbance during the nesting season increases its vulnerability to impacts that occur at breeding sites. In addition, crucial breeding areas are only partially identified, so management efforts may not adequately address conservation needs. Throughout its breeding range, the Mountain Plover is classified as uncommon to relatively common, but the species exists in low densities. The Mountain Plover was previously petitioned for listing as Threatened under the federal ESA on 2 separate occasions, further emphasizing the need to adequately determine population status (USFWS 1999, 2010).

The Upland Sandpiper is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSSU, Tier II classification in the SWAP (WGFD 2010). Populations in eastern Wyoming may be experiencing serious declines due to habitat conversions, the encroachment of woody vegetation into grassland habitats, humanization, and the invasion of noxious species, all of which severely degrade breeding habitat for this species. This species is also sensitive to human disturbance during the breeding season. Population status and trends are largely unknown in Wyoming, and current monitoring programs do not adequately track this species because populations occur at low densities.

The Long-billed Curlew is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSS3, Tier II classification in the SWAP (WGFD 2010). Although the breeding status is well known in the northwestern portion of Wyoming and monitoring is on-going, populations in eastern Wyoming are not well documented and may be declining significantly. Habitat degradation is one of the most considerable threats to this species, particularly in the Great Basin grasslands.

The Burrowing Owl is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSSU, Tier I classification in the SWAP (WGFD 2010). It has experienced range-wide contractions due to habitat loss and degradation and the elimination of burrowing rodents. While distribution of this species is understood in the state, there is concern about the impacts of on-going and proposed oil, gas, and wind energy development in Burrowing Owl habitat in Wyoming, and informed management decisions are difficult to make without adequate occupancy and population trend information.

Wyoming Governor's Endangered Species Account funds were used to hire a seasonal field biologist from April through September in 2013 and 2014 to assist the Department's Nongame Bird Biologist with implementing this long-term, targeted monitoring program. We used existing information to identify preferred breeding habitat for our focal species, and followed standardized, peer-reviewed survey techniques specifically designed for each of our focal SGCN to delineate our survey routes (Figures 2-5).

Wyoming contains substantial areas of known and potential habitat for these SGCN, including areas where habitat degradation and conflicts with industrialization are likely to occur in the near future. However, due in part to personnel and funding constraints, important breeding areas and population status are only partially identified, which makes effective statewide management decisions challenging. Once we are able to implement targeted monitoring for these species, we can use survey results to address concerns, data deficiencies, and conservation actions presented in the Wyoming Bird Conservation Plan (Nicholoff 2003), Grassland Plan (WGFD 2006), and SWAP (2010). Moreover, avian grassland species are equally dependent on quality habitat in their breeding, migration, and winter ranges (Knopf 1996). Thus, the results of this project will help inform management decisions, address conservation concerns, and direct conservation actions on these species' breeding grounds in Wyoming. Results will also enhance our ability to advance conservation and management of grassland birds and their habitats through full life-cycle conservation.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature General Fund Appropriations, for which the Department is extremely grateful. We also thank Governor Mead for providing funding assistance during the previous 2 years through the Wyoming Governor's Endangered Species Account, which enabled us to implement 90 new survey routes for Species of Greatest Conservation Need. We extend special thanks to the numerous Department personnel for their valuable monitoring assistance; individuals are identified in each of the SGCN tables.

LITERATURE CITED

Estes, J. R., R. J. Tyrl, and J. N. Brunken (Editors). 1982. Grasses and grasslands; systematics and ecology. University of Oklahoma Press, Norman, USA.

Fellows, S. D., and S. L. Jones. 2009. Status assessment and conservation action plan for the Long-billed Curlew (*Numenius americanus*). U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication, FWS/BTP-R6012-2009, Washington, D.C., USA.

Knopf, F. L. 1992. Faunal mixing, faunal integrity, and the biopolitical template for diversity conservation. Transactions of the North American Wildlife and Natural Resources Conference 57:330-342.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. Studies in Avian Biology 15:247-257.

Knopf, F. L. 1996. Prairie legacies – birds. Pages 135-148 *in* Prairie conservation: preserving North America's most endangered ecosystem (F. B. Samson and F. L. Knopf, Editors). Island Press, Covelo, California, USA.

Knopf, F. L., and F. B. Samson. 1995. Conserving the biotic integrity of the Great Plains. Pages 121-133 *in* Conservation of Great Plains ecosystems: current science, future options (S. Johnson and A. Bouzaher, Editors). Kluwer Academic Press, Dordrecht, The Netherlands.

Knopf F. L., and F. B. Samson. 1997. Conservation of grassland vertebrates. Pages 273-289 *in* Ecology and conservation of Great Plains vertebrates (F. L. Knopf and F. B. Samson, Editors). Springer, New York, New York, USA.

Mengel, R. M. 1970. The North American central plains as an isolating agent in bird speciation. Pages 280-340 *in* Pleistocene and recent environments of the central Great Plains (W. Dort and J. K. Jones, Editors). University of Kansas Press, Lawrence, USA.

Nicholoff, S. H. (Compiler). 2003. Wyoming bird conservation plan. Version 2.0. Wyoming Partners in Flight. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of birds, mammals, amphibians, and reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Samson, F. B., F. L. Knopf, and W. R. Ostlie. 1988. Grasslands. Pages 437-472 *in* Status and trends of the nation's biological resources, Volume 2 (M. J. Mac, P. A. Opler, C. E. Pucket Haecker, and P. D. Doran, Editors). U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia, USA. www.nwrc.usgs.gov/sandt/Grasslnd.pdf (accessed 27 August 2014).

Williams, J., and P. Diebel. 1996. The economic value of prairie. Pages 19-35 *in* Prairie conservation: preserving North America's most endangered ecosystem (F. B. Samson and F. L. Knopf, Editors). Island Press, Covelo, California, USA.

United States Fish and Wildlife Service [USFWS]. 1999. Endangered and threatened wildlife and plants – proposed threatened status for the Mountain Plover. Federal Register 64(30):7587-7601.

United States Fish and Wildlife Service [USFWS]. 2010. Endangered and threatened wildlife and plants – listing the Mountain Plover as threatened. Federal Register 75(124):37353-37358.

Wyoming Game and Fish Department [WGFD]. 2006. A plan for bird and mammal Species of Greatest Conservation Need in eastern Wyoming grasslands. Wyoming Game and Fish Department, Cheyenne, USA.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming State Wildlife Action Plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Endemic and secondary species associated with the Great Plains grasslands (Mendel 1970). Species that breed in Wyoming are denoted in bold. Native Species Status (NSS) and Tier are from the Wyoming State Wildlife Action Plan (WGFD 2010). NSSU = Native Species Status Unknown. Table excludes wetlands-associated species, and those species that have stronger ecological associations with sagebrush (*Artemisia* spp.) landscapes of the Great Basin.

Common name	Scientific name	Seasonal status	Native species status and tier
Endemic species			
Ferruginous Hawk	*Buteo regalis*	**Year-round**	**NSSU, I**
Mountain Plover	*Charadrius montanus*	**Summer**	**NSSU, I**
Long-billed Curlew	*Numenius americanus*	**Summer**	**NSS3, II**
Marbled Godwit	*Limosa fedoa*	Migrant	
Wilson's Phalarope	***Phalaropus tricolor***	**Summer**	
Franklin's Gull	***Larus pipixcan***	**Summer**	**NSS3, II**
Sprague's Pipit	*Anthus spragueii*	Migrant	
Chestnut-collared Longspur	***Calcarius ornatus***	**Summer**	**NSS4, II**
McCown's Longspur	***Rhynchophanes mccownii***	**Summer**	**NSS4, II**
Cassin's Sparrow	*Peucaea cassinii*	Accidental	
Lark Bunting	***Calamospiza melanocorys***	**Summer**	**NSS4, II**
Baird's Sparrow	***Ammodramus bairdii***	**Summer**	
Secondary species			
Sharp-tailed Grouse	***Tympanuchus phasianellus***	**Year-round**	**NSS4, II**
Greater Prairie-Chicken	*Tympanuchus cupido*	Accidental	
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*		
Mississippi Kite	*Ictinia mississippiensis*	Accidental	
Northern Harrier	***Circus cyaneus***	**Summer**	
Swainson's Hawk	***Buteo swainsoni***	**Summer**	**NSSU, II**
Upland Sandpiper	***Bartramia longicauda***	**Summer**	**NSSU, II**
Burrowing Owl	***Athene cunicularia***	**Summer**	**NSSU, I**
Short-eared Owl	***Asio flammeus***	**Year-round**	**NSS4, II**
Prairie Falcon	***Falco mexicanus***	**Year-round**	
Horned Lark	***Eremophila alpestris***	**Year-round**	
Clay-colored Sparrow	***Spizella pallida***	**Summer**	
Vesper Sparrow	***Pooecetes gramineus***	**Summer**	
Lark Sparrow	***Chondestes grammacus***	**Summer**	
Savannah Sparrow	***Passerculus sandwichensis***	**Summer**	
Grasshopper Sparrow	***Ammodramus savannarum***	**Summer**	**NSS4, II**
Henslow's Sparrow	*Ammodramus henslowii*		
Dickcissel	***Spiza americana***	**Summer**	**NSS4, II**
Eastern Meadowlark	*Sturnella magna*	Accidental	
Western Meadowlark	***Sturnella neglecta***	**Summer**	

Table 2. Results from the 1st year of surveys for Mountain Plover (*Charadrius montanus*) in Wyoming. We conducted 1 Mountain Plover (MOUP) survey per route in 2015 during the pre-fledging and brood-rearing phase, from the last 10 days of June through the 1st week of July.

MOUP route	Assigned observer	Survey date	Total MOUP	Comments and Species of Greatest Conservation Need (SGCN) detected
Arminto	Heather O'Brien	1 and 2 July	0	Grasses very tall and abundant
Bucknam Road	Daniel Beach	none	n/a	Route not conducted
Bush Rim	Andrea Orabona	2 July	7	SGCN = Greater Sage-Grouse (4 adults, 4 juveniles)
Fetterman Road	Bob Lanka	23 June	0	Grass is multi-layered; cannot see birds on ground
Great Divide Basin	Greg Hiatt	4 July	3	Grass and saltbush are tall
Laramie Basin	Lee Knox	none	n/a	Route not conducted
Lysite	Greg Anderson	2 July	0	Original route modified due to access issues
Marshall Road	Brian Zinke	13 July	0	SGCN = McCown's Longspur
Mexican Flats	Tony Mong	none	n/a	Route not conducted
Moneta	Zack Walker	n/a	n/a	Route dropped due to access issues
North Cody	Tim Woolley	30 June	0	Modified route due to lack of 2-track on original route
Polecat Bench	Tim Woolley	1 July	1	3 juvenile MOUP; SGCN = 10 Long-billed Curlew at PO 11 (3) and 21 (7)
Red Desert	Stan Harter	21 July	2	Tall grass and vegetation; hard to see birds on ground
Shirley Basin	Will Schultz	26 and 29 June	25	Split date on survey due to continued rain
Thunder Basin Central	Joe Sandrini	20 June	0	Lots of prairie dogs; many more than last year
Thunder Basin North	Joe Sandrini	29 June	13	4 juvenile MOUP; lots of prairie dogs; grass taller
Thunder Basin South	Willow Hibbs	25 June	4	2 juvenile MOUP
Total routes = 17		*Total Adult MOUP = 55*		*Total routes completed out of 17 = 13 (1 route was dropped)*

Table 3. Results from the 1st year of surveys for Upland Sandpiper (*Bartramia longicauda*) in Wyoming. We surveyed Upland Sandpipers (UPSA) from early June to mid-July 2015, when they are on their breeding grounds in Wyoming. We attempted to conduct 2 surveys along each route using the same observer per route, with surveys separated by a minimum of 10 and maximum of 14 days to incorporate the range of the breeding season and facilitate detection.

UPSA route	Assigned observer	1st replicate	Total UPSA	2nd replicate	Total UPSA	Comments and Species of Greatest Conservation Need (SGCN) detected
Bariod Road	Andrea Orabona	25 June	3	none	n/a	Access issue, so route was modified and only one survey could be conducted
Douglas	Willow Hibbs	10 July	0	none	n/a	Route was originally assigned to Rod Lebert; Willow Hibbs filled in so 1 route was completed
East Sheridan	Dustin Shorma	23 June	0	6 July	0	SGCN = Lark Bunting; loud traffic and noise on Lower Prairie Dog Road made hearing difficult
East Yoder	Grant Frost	19 June	0	29 June	2	SGCN = Burrowing Owl, Ferruginous Hawk, Grasshopper Sparrow, Lark Bunting, Swainson's Hawk, Sage Thrasher
Glendo	Martin Hicks	24 June	4	none	n/a	Ran old route once; UTMs may not correspond with current route
Goldie Divide	Andrea Orabona	12 June	5	25 June	5	SGCN = Bobolink, Grasshopper Sparrow, Lark Bunting
Hulett	Erika Peckham	10 June	5	17 July	0	SGCN = Grasshopper Sparrow, Lark Bunting
Jireh Road	Willow Hibbs	19 June	1	29 June	0	SGCN = Burrowing Owl, Ferruginous Hawk, Lark Bunting

Table 3. Continued.

UPSA route	Assigned observer	1st replicate	Total UPSA	2nd replicate	Total UPSA	Comments and Species of Greatest Conservation Need (SGCN) detected
Lusk North	Brady Vandeberg	2 June	0	13 June	2	SGCN = Long-billed Curlew
Lusk South	Brady Vandeberg	3 June	4	14 June	1	SGCN = Burrowing Owl, Long-billed Curlew
Moorcroft	John Davis	29 June	19	13 and 14 July	6	Ended at stop 18 (injured wildlife call); finished route on 14 July
Pleasantdale	Dustin Kirsch	30 June	4	none	n/a	SGCN = Lark Bunting
Rockpile	Jackie Otto	12 June	7	5 July	5	SGCN = Mountain Plover at stops 5, 14, 17, 20, 22
Rocky Point	Andrea Orabona	11 June	0	none	n/a	SGCN = Burrowing Owl, Grasshopper Sparrow, Long-billed Curlew, Swainson's Hawk
Seely	Chris Teter	1 July	4	10 July	1	SGCN = Ferruginous Hawk
West Sheridan	Bruce Scigliano	9 June	0	15 June	0	Did not record any other species detected on route
Total routes = 16		*Total UPSA = 56*		*Total UPSA = 22*		*Total replicates conducted out of 32 = 27*

Table 4. Results from the 1st year of surveys for Long-billed Curlew (*Numenius americanus*) in Wyoming. We surveyed Long-billed Curlews (LBCU) during the pre-incubation and courtship stages, between 21 April and 15 May 2015, when birds are easier to detect. We attempted to conduct 2 surveys along each route using the same observer per route, with surveys separated by a minimum of 7 and maximum of 14 days.

LBCU route	Assigned observer	1st replicate	Total LBCU	2nd replicate	Total LBCU	Comments
Arvada	Brian Zinke	6 May	0	18 May	1	Surveys completed
Beckton	Brian Zinke	5 May	2	19 May	1	Surveys completed
Buffalo South	Dan Thiele	1 May	0	12 May	0	Surveys completed
Carpenter West	Rachel Nuss	8 May	0	15 May	0	Surveys completed
Chapman Bench	Doug McWhirter	1 May	8	12 May	6	Surveys completed
Cheyenne River	Brian Zinke	30 April	0	13 May	0	Surveys completed
Chugwater Flats	Ian Tator	13 May	0	17 May	0	Surveys completed
Clareton East	Joe Sandrini	29 April	0	9 May	0	Route is noisy, lots of traffic; shift in 2016
Dull Center	Willow Hibbs	5 May	0	14 May	0	Surveys completed
East Bill	Brian Zinke	29 April	0	none	n/a	Completed 1 survey, then new observer
East Bill (not actual route)	Rod Lebert	1 May	0	12 May	0	Used slightly different UTMs than on route data sheet
Elk Refuge	Susan Patla	28 April	17	13 May	6	Surveys completed
Glenrock East	Gary Boyd, Cody Bish	3 May	0	14 May	0	Surveys completed; Cody Bish ran 2nd replicate

Table 4. Continued.

LBCU route	Assigned observer	1st replicate	Total LBCU	2nd replicate	Total LBCU	Comments
Goshen Hole	Kim Szcodronski	1 May	0	15 May	0	Surveys completed
Grand Teton	Aly Courtemanch	27 April	19	5 May	11	Surveys completed; Bev Boynton ran 2nd replicate (out of order)
Harmony Heights	Kim Szcodronski	29 April	0	14 May	0	Surveys completed
Hawk Springs	Steve Tessman	30 April	0	13 May	0	Surveys completed
Heward Ranch	Kim Szcodronski	2 May	0	17 May	0	Surveys completed
Horse Creek	Jill Randall	10 May	42	18 May	33	Surveys completed
Huntley	Andrea Orabona	13 May	4	17 May	0	Surveys completed
Jay Em	Andrea Orabona	14 May	1	18 May	0	Surveys completed
Kaan Road	Brady Vandeberg	1 May	3	15 May	0	Surveys completed
Lance Creek	Willow Hibbs	6 May	0	none	n/a	Only 1 survey completed
Little Medicine	Will Schultz	5 May	0	13 May	0	Surveys completed
Meadowdale West	Martin Hicks	15 May	0	none	n/a	Only 1 survey completed
Meriden	Bob Lanka	7 May	0	14 May	0	Surveys completed
New Fork	Dean Clause	4 May	18	none	n/a	Only 1 survey completed

Table 4. Continued.

LBCU route	Assigned observer	1st replicate	Total LBCU	2nd replicate	Total LBCU	Comments
Node	Brady Vandeberg	30 April	4	14 May	1	Surveys completed
North Gillette	Erika Peckham	7 May	0	15 May	0	Surveys completed
Osage	Troy Achterhof	8 May	0	15 May	0	Surveys completed
Veteran	Kim Szcodronski	30 April	0	13 May	0	Surveys completed
Weston	Erika Peckham	29 April	0	none	n/a	Only 1 survey completed
Wyarno	Tim Thomas	8 May	0	none	n/a	Only 1 survey completed
Total routes = 32		*Total LBCU = 118*		*Total LBCU = 59*		*Total replicates conducted out of 64 = 57*

Table 5. Results from the 1st year of surveys for Burrowing Owl (*Athene cunicularia*) in Wyoming. We surveyed Burrowing Owls (BUOW) from 15 April to 7 August 2015 to encompass each of the 3 nesting stages (pre-incubation, incubation/hatching, and nestling). We attempted to conduct 3 surveys of each route, with each survey occurring during a 30-day survey window and separated from the previous survey by at least 10 days. Ad = adult BUOW, Juv = juvenile BUOW.

BUOW route	Assigned observer	1st replicate	Total BUOW	2nd replicate	Total BUOW	3rd replicate	Total BUOW	Comments and Species of Greatest Conservation Need (SGCN) detected
Agate Flat	Andrea Orabona	none	n/a	15 June	0	16 July	0	SGCN = Brewer's Sparrow, Sagebrush Sparrow, Sage Thrasher; added route later so only 2 replicates conducted
Bar X	Patrick Burke	1 June	1 Ad	30 June	0	7 August	0	SGCN = Brewer's Sparrow, Sagebrush Sparrow, Sage Thrasher; 1st weathered out
Fontenelle	Tom Christiansen	15 May	1 Ad	26 June	2 Ad 1 Juv 1 nest	29 July	1 Ad	SGCN = Sage Thrasher
Greybull North	Leslie Schreiber	none	n/a	16 June	0	23 July	0	Inclement weather during 1st survey period
Hiatville West	Leslie Schreiber	none	n/a	12 June	0	24 July	0	Tim Woolley conducted 2nd replicate
Jonah	Kim Szcodronski	19 May	0	9 June	0	1 August	3 Ad	Jordan Kraft conducted 3rd replicate and is now the observer
North Dunes	Andrea Orabona	2 June	0	16 June	0	6 August	1 Ad	SGCN = Brewer's Sparrow, Sagebrush Sparrow, Sage Thrasher, Lark Bunting
North Huntley	Grant Frost	1 May	8 Ad	18 June	6 Ad 3 nests	22 July	3 Ad 7 Juv 2 nests	BUOW nests at NH 1, 4, 5, 9; BUOW juveniles at NH 1 (3), 4 (4); SGCN = Upland Sandpiper

Table 5. Continued.

BUOW route	Assigned observer	1st replicate	Total BUOW	2nd replicate	Total BUOW	3rd replicate	Total BUOW	Comments and Species of Greatest Conservation Need (SGCN) detected
South Wamsutter	Kim Szcodronski	20 May	0	11 June	1 Ad	7 July	4 Ad 1 Juv	Need to modify SW 9 and 10 due to private access
Tipperary Road	Brian Zinke	18 May	3 Ad	9 June	3 Ad 1 Juv 1 nest	6 July	29 Ad 2 Juv 1 nest	BUOW nest at TR 5; SGCN = Short-eared Owl (TR 1, 7, 9, 10)
Upton South	Joe Sandrini	11 May	0	19 June	0	22 July	0	SGCN = Brewer's Sparrow, Lark Bunting, Swainson's Hawk; landowners report BUOW on prairie dog towns behind hills
Wamsutter	Kim Szcodronski	8 May	0	10 June	3 Ad	7 July	0	Brian Zinke conducted 3rd replicate and did not survey WA 1-6 due to access concerns
Wamsutter Highway	Kim Szcodronski	9 May	0	11 June	0	8 July	2 Ad 2 Juv 1 nest	BUOW at WH 10; Brian Zinke conducted 3rd replicate
West Gillette	Erika Peckham	17 May	0	none	n/a	none	n/a	SGCN = Lark Bunting; 2nd replicate started on 16 July but injured wildlife call came in
Wildcat Butte	Jeff Short	none	n/a	23 June	1 Ad	25 July	0	Prairie dogs on WB 1, 5, 7, 8
Total routes = 15		*Total BUOW = 13 adults*		*Total BUOW = 16 adults, 2 juveniles, 5 nests*		*Total BUOW = 43 adults, 12 juveniles, 4 nests*		*Total replicates conducted out of 45 = 39*

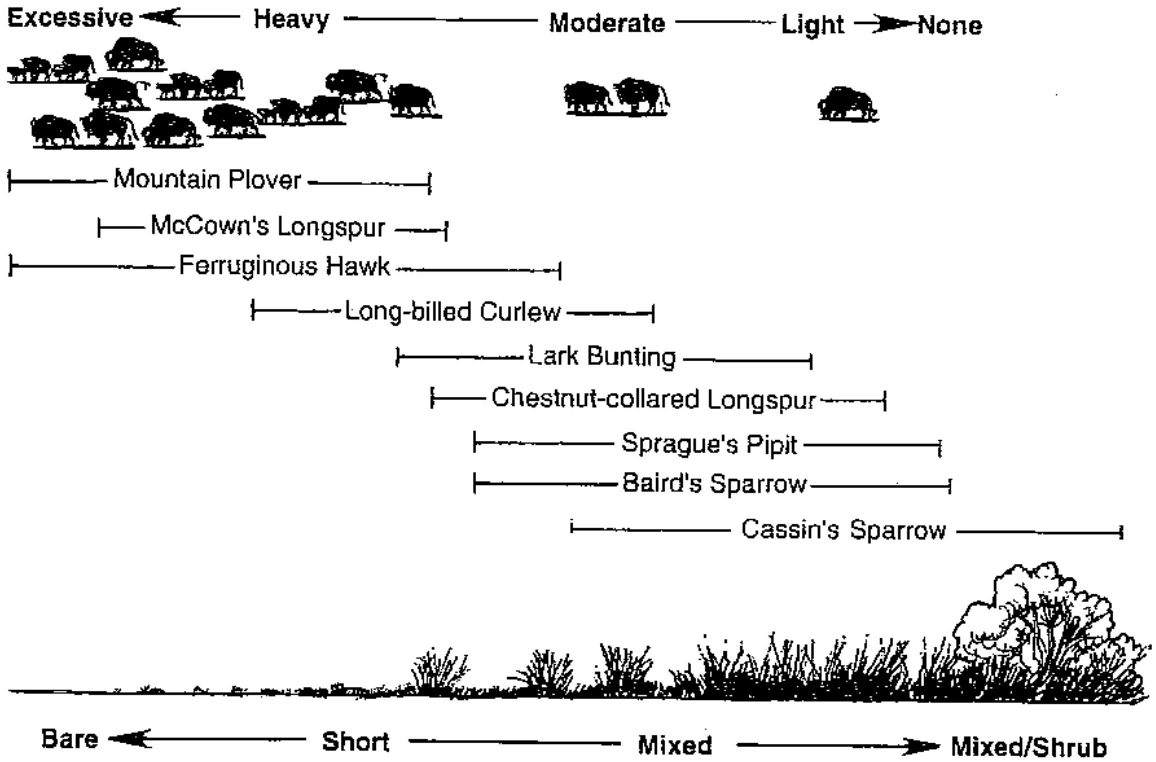

Figure 1. Distributions of avian species endemic to the Great Plains in relation to grassland type and historical grazing pressure (Knopf 1996).

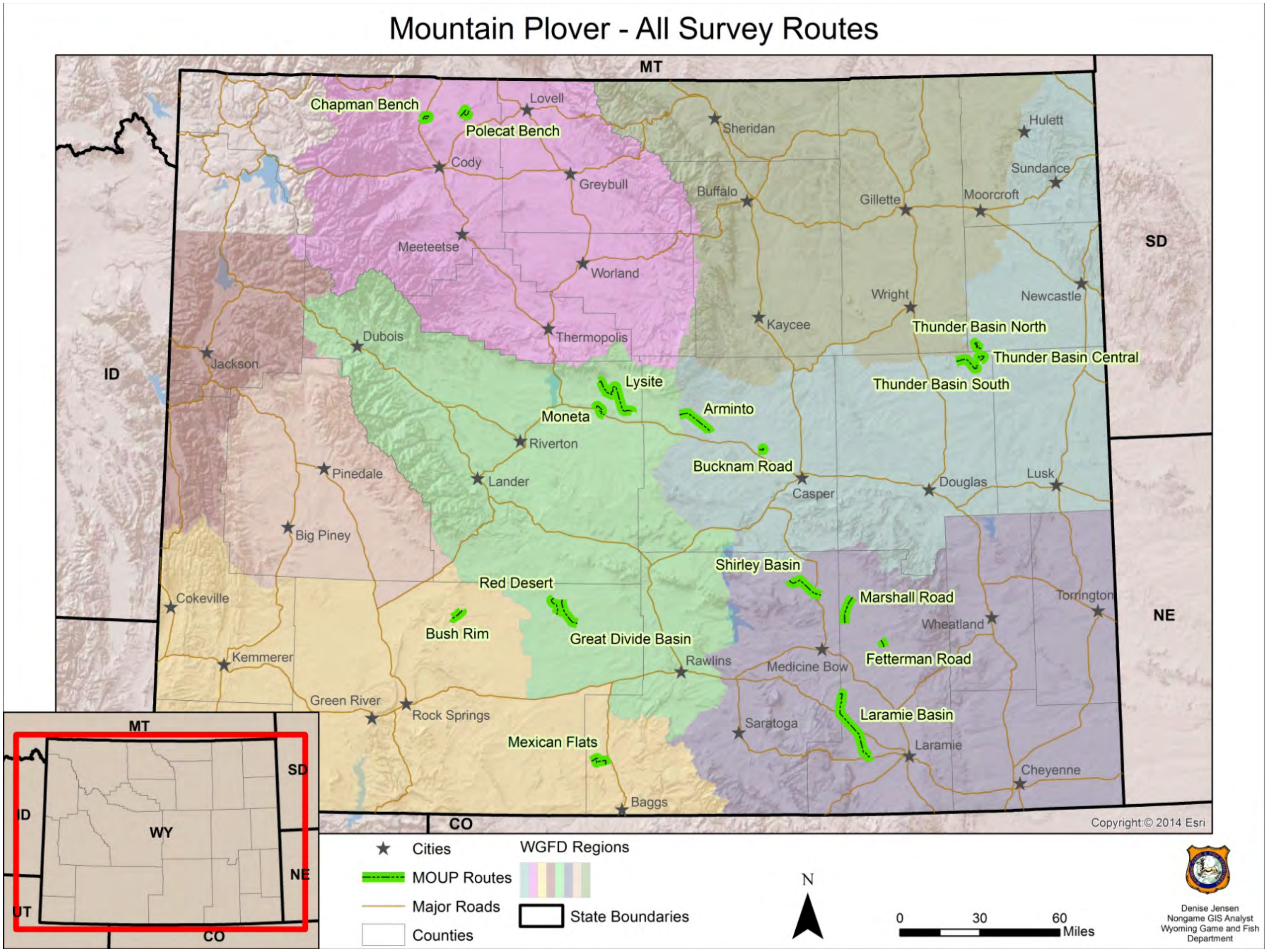

Figure 2. Survey routes we established in 2013 and 2014 for monitoring Mountain Plovers (*Charadrius montanus*) in Wyoming.

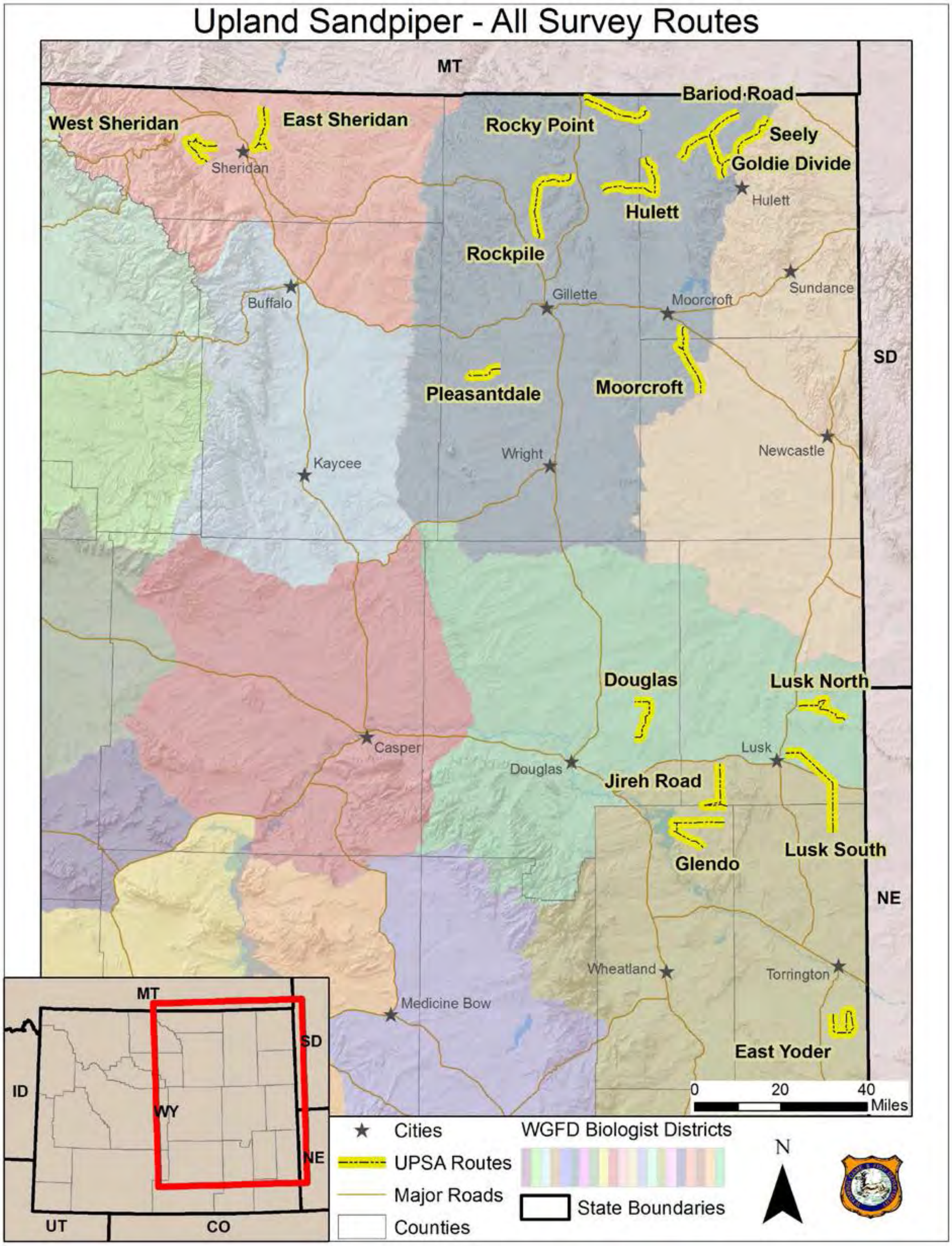

Figure 3. Survey routes we established in 2013 and 2014 for monitoring Upland Sandpipers (*Bartramia longicauda*) in Wyoming.

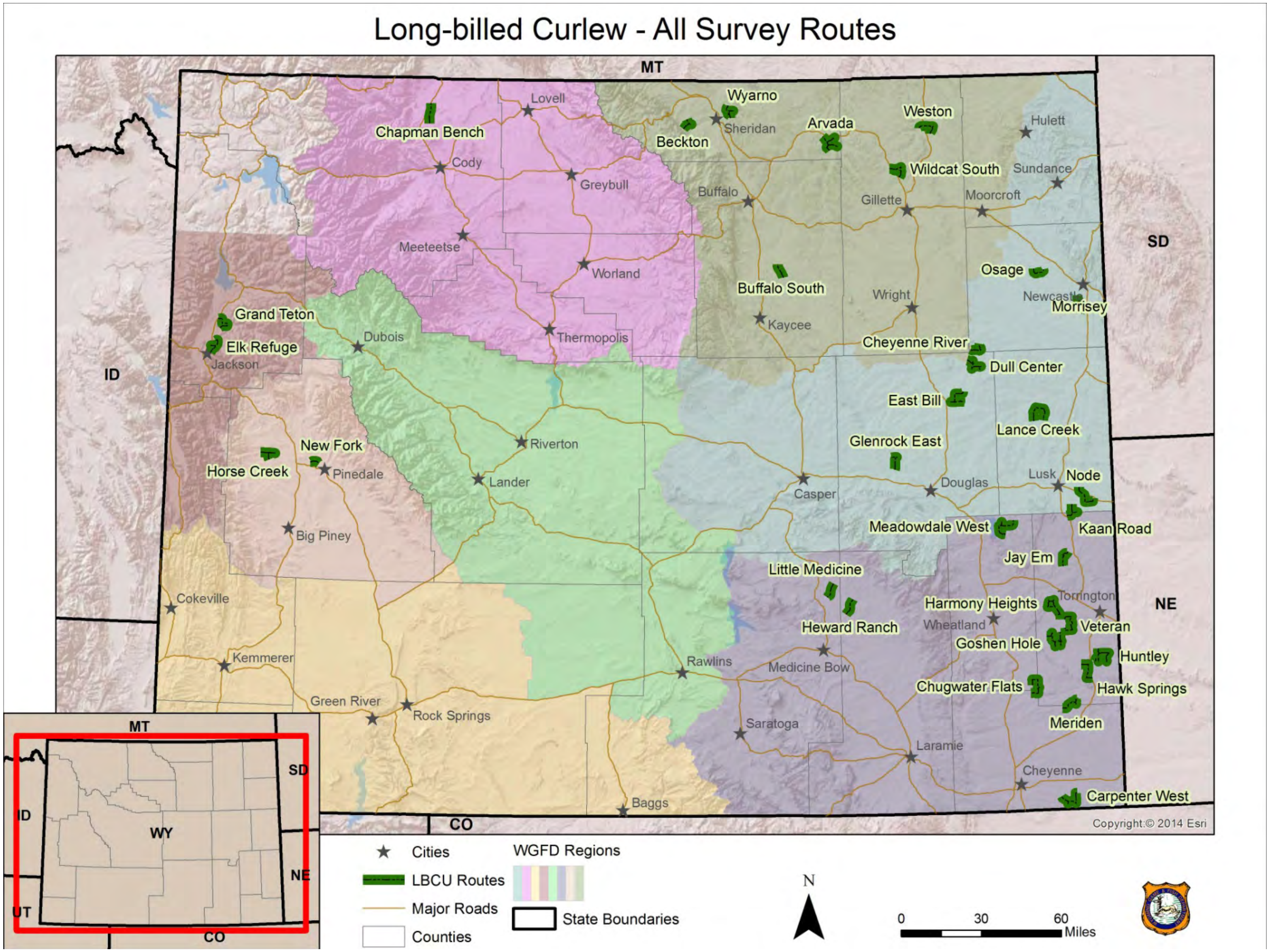

Figure 4. Survey routes we established in 2013 and 2014 for monitoring Long-billed Curlews (*Numenius americanus*) in Wyoming.

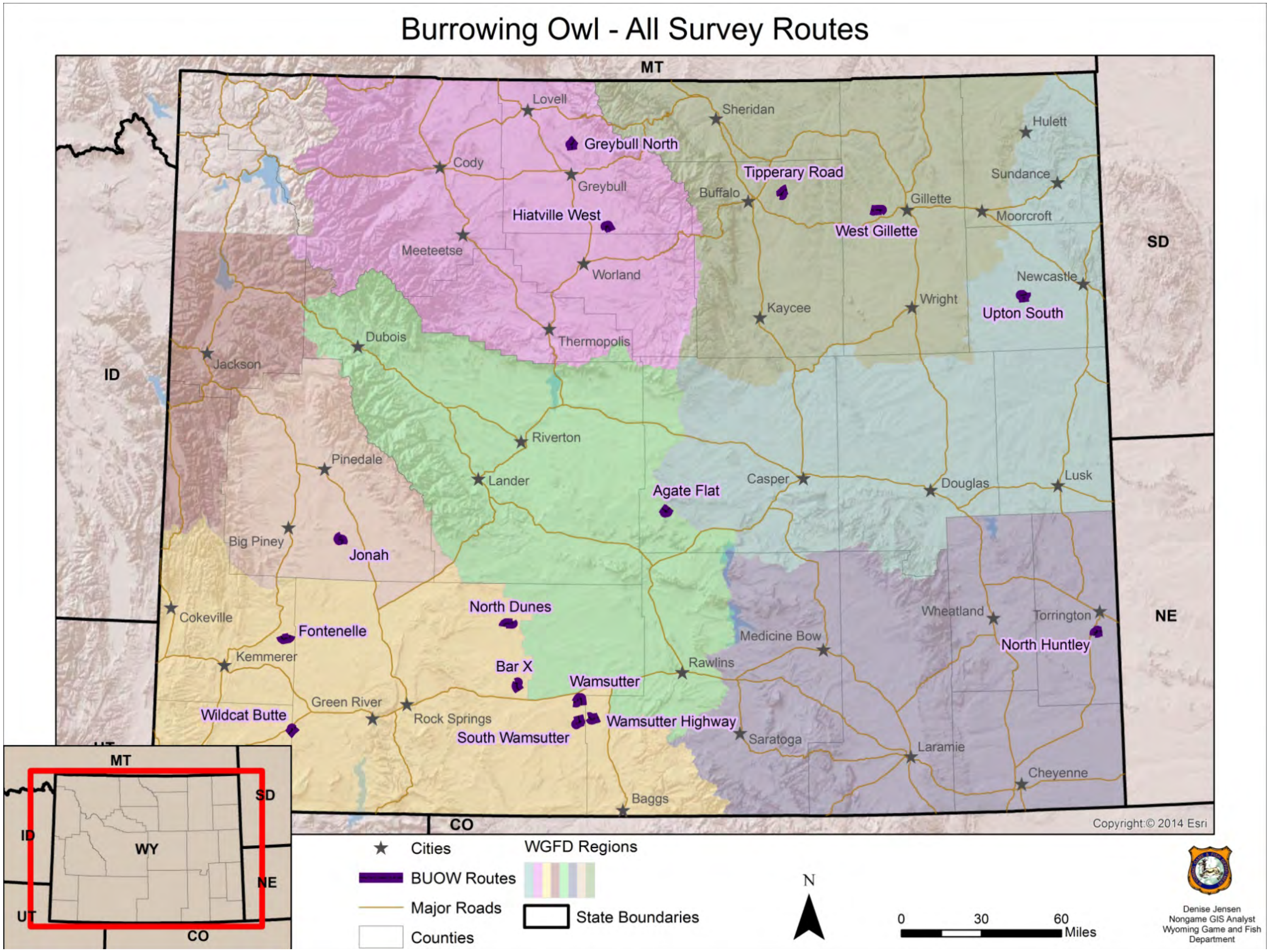

Figure 5. Survey routes we established in 2013 and 2014 for monitoring Burrowing Owls (*Athene cunicularia*) in Wyoming.

SPECIES OF GREATEST CONSERVATION NEED – MAMMALS

SURVEILLANCE OF HIBERNATING BATS AND ENVIRONMENTAL CONDITIONS AT CAVES AND ABANDONED MINES IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 11 March 2015 – 10 March 2016

PREPARED BY: Laura Beard, Nongame Biologist

ABSTRACT

Wyoming bat species that hibernate in caves and abandoned mines are at risk of contracting white-nose syndrome as the causative fungus, *Pseudogymnoascus destructans*, continues to spread. Three species of bats found in Wyoming are known to be particularly vulnerable to white-nose syndrome in their eastern range, including the little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), and American perimyotis (*Perimyotis subflavus*). Populations of bats in caves and abandoned mines in Wyoming are orders of magnitude smaller than those in eastern North America, making it difficult to determine if white-nose syndrome will affect populations at the same scale, should the fungus be introduced in the West. The major objectives of this project were to understand the environmental conditions inside hibernacula used by bats in Wyoming, especially myotis hibernacula and caves at increased risk for *P. destructans* introduction; census hibernating bats present at hibernacula; and monitor for the potential arrival of the fungus in Wyoming. Conditions for optimal growth of *P. destructans* are specific, and environmental conditions of caves and abandoned mines in Wyoming are still largely unknown. Data quantifying interior temperatures and humidity of caves and abandoned mines in Wyoming were very limited prior to this project; the data we have gathered indicate that the climate of many caves in Wyoming will fall within the growth range for the fungus, though some may be outside the optimal range. We successfully surveyed 18 sites for hibernating bats, and documented 5 previously unknown hibernacula. Four of these had Townsend's big-eared bats (*Corynorhinus townsendii*) present, while the 5th was occupied by western small-footed bats (*M. ciliolabrum*) and a big brown bat (*Eptesicus fuscus*). Very few little brown bats have been found during winter cave and mine surveys in Wyoming, which calls into question the assumption that this species favors these structures for hibernation in the state. Beginning in 2014, we have participated in a national

effort to identify *P. destructans* infected sites. Thus far, no sites in Wyoming have tested positive for the fungus.

INTRODUCTION

Bats that hibernate in caves and abandoned mines in North America are at risk of contracting white-nose syndrome (WNS), a disease that is causing major declines in bat populations in the eastern US and Canada. WNS is named after a conspicuous white fungus, *Pseudogymnoascus destructans,* which infects the skin of hibernating bats, causing increased energy use and prematurely depleted fat stores (Verant et al. 2014). Mortality due to *P. destructans* infection results from a cascade of physiological disturbances, beginning with increased energy use and changes in blood chemistry that lead to increased water, electrolyte, and fat reserve loss, ultimately resulting in death (Verant et al. 2014). As of 9 March 2016, WNS and *P. destructans* have been confirmed in 27 states and 5 Canadian provinces (USFWS 2016). In the winter of 2015, *P. destructans* was found in a cave in eastern Nebraska; this is the nearest detection of the fungus to Wyoming to-date (USFWS 2016).

Four species found in Wyoming are known to be vulnerable to WNS in the East: little brown myotis (*Myotis lucifugus*); American perimyotis (*Perimyotis subflavus*)*,* formerly the eastern pipistrelle or tri-colored bat (*Pipistrellus subflavus)*; northern long-eared myotis (*M. septentrionalis*); and big brown bat (*Eptesicus fuscus*; Coleman and Reichard 2014). The Virginia big-eared bat (*Corynorhinus townsendii virginianus)*, a subspecies of Townsend's big eared bat (*C. townsendii)*, is known to carry the fungus while exhibiting no ill effects (Coleman and Reichard 2014). In Wyoming, Townsend's big-eared bats have been observed sharing hibernacula with little brown and western small-footed myotis (*M. ciliolabrum*), making them a possible vector of infection for vulnerable species. Northern long-eared myotis and American perimyotis are rare in Wyoming; however, the little brown myotis and big brown bat are widespread. The little brown myotis is one of the most commonly captured and reported bat species in the state (Filipi et al. 2009; Johnson and Grenier 2010a, b; Cudworth et al. 2011; Abel and Grenier 2012b, c; Yandow and Grenier 2013, 2014; Yandow and Beard 2015). It is unknown how WNS will affect the rest of Wyoming's bat species, as they have yet to be exposed to the fungus. Some western species of myotis are considered analogous to an eastern species, such as the long-eared myotis (*M. evotis)* to the northern long-eared myotis, with an important difference being that the western bats consistently roost in much smaller numbers than their eastern counterparts (Knudsen et al. 2013). This pattern holds true for the eastern and western populations of little brown myotis, as well. For example, there are 88 known little brown myotis roosts in Wyoming; however, survey data suggest the majority of these roosts support <50 individuals each. As the number of bats present at a roost site can affect the speed at which *P. destructans* is able to spread between individuals, this difference in roosting density may impact the reservoir competence of Western roosts (Langwig et al. 2012).

Conditions for optimal growth of *P. destructans* include cool temperatures (12.5-15.8^{o}C) and high humidity, though the total growth range of the fungus is larger (1^{-}19^{o}C; Flory et al. 2012, Coleman and Reichard 2014). If the fungus is introduced in Wyoming, habitats in hibernacula, including caves and abandoned mines, must provide suitable conditions that would support and promote the growth of *P. destructans* for it to become established. There are limited historical data quantifying interior temperatures and humidity of caves and abandoned mines in Wyoming. All data prior to this project were taken during single site visits and were taken from interior locations that were not always adjacent to the surfaces where bats roost during hibernation. Thus, our understanding of how these parameters vary inter- and intra-seasonally has been limited and probably does not reflect the environmental conditions experienced by hibernating bats. It has been hypothesized that caves and abandoned mines in Wyoming may be cooler and dryer than those in eastern North America and, because of this, may not be favorable for optimal growth of *P. destructans*. However, *P. destructans* has been shown to survive in suboptimal conditions, which suggests it could become established in western states. For example, the fungus has the ability to survive as viable spores for multiple years in dry conditions, such as those found on some cave floors (Hoyt et al. 2015). Understanding the climate conditions of caves in Wyoming and throughout the West is critical to predicting the persistence and spread of the fungus as it approaches the state. The goal of this project is threefold. Our first objective was to assess whether suitable conditions for *P. destructans* exist within caves and abandoned mines in Wyoming. In a previous report, we concluded that conditions in many Wyoming caves are within the growth range of the fungus during hibernation, though they may be outside the optimal growth range (Beard 2015). In the 2015-2016 winter season, we shifted our focus to the second goal of this study: to census hibernating bats before the arrival of WNS. The final goal is to collect fungal spore samples from caves and mines in Wyoming to test for the presence of *P. destructans* in the state to aid in early detection of *P. destructans* and to help predict the susceptibility of western bat species to WNS.

METHODS

Temperature and humidity monitoring

We selected survey sites that we considered to be at risk for contracting *P. destructans* due to human and bat visitation. While selecting sites, we considered historical use by hibernating bats, recreational pressure, and whether the roost was gated (R. Truex, personal communication). We chose to survey roosts that had not been surveyed in the last 3 years in an attempt to minimize disturbance to bats and their environment. Within each site, we deployed iButton devices (data loggers; DS1923-F5, Maxim Integrated, San Jose, CA). Each data logger was placed in an iButton key ring (DS9093A+, Maxim Integrated, San Jose, CA) before being deployed.

Each data logger was uniquely numbered with a 3-digit numerical code (ID no.). We programmed data loggers to record temperature and humidity once every 3-6 hours. When a data logger was deployed, we recorded the ID no., description of location, name of the chamber or passage, and the method we used to attach the data logger. Data loggers were placed inside the entrance and at 1-2 locations exterior to the site. We then deployed data loggers throughout the cave, within hibernation zones when possible. Hibernation zones were identified as the area from where the first bat was seen during any hibernation survey to the area where the last bat was seen during any hibernation survey. We adhered to all WNS survey and decontamination protocols outlined in the National WNS Decontamination Protocol (USFWS 2012).

Hibernation surveys and swabbing

During the winter of 2015-2016, our focus shifted to completing hibernation surveys for sites where there was no winter survey on record or where the survey had taken place before 2012. At sites visited during the hibernation season, we counted individual bats and attempted to identify each bat to species.

In 2014, we began participating in the US Fish and Wildlife Service WNS surveillance program, using hibernation surveys to collect samples to be tested for the presence of *P. destructans*. In one site where the total bat population was expected to exceed 15, we swabbed hibernating bats, cave walls, and the cave floor for the presence of *P. destructans* (USGS National Wildlife Health Center 2013). All samples were sent to the National Wildlife Health Center for genetic analysis. Starting in December 2015, we began collecting samples for a second National Wildlife Health Center project to identify native fungus on bats before the arrival of *P. destructans*. We swabbed bats at 3 sites for native fungal spores (USGS National Wildlife Health Center 2015). When sampling for both projects in the same cave, we took 2 sets of swabs from a subset of bats in order to minimize disturbance.

RESULTS

Temperature and humidity monitoring

In general, the environmental data provide a multi-seasonal picture of the environment in each cave, although the monitoring period at each site varied. None of these sites were monitored over the hibernation season; however, the microclimates recorded in the interiors of 3 of the caves (Sites 40, 71, and 133) were very similar to previous data collected at the same locations within the caves throughout the year, making these data relevant to a discussion of hibernacula conditions, as well as fungal persistence within these sites (Beard 2015). Figures 1-8 show temperature and humidity for each cave monitored with data loggers during this time. Average temperatures in the hibernation zone for all sites ranged from 4.73-9.44^{o}C. The total range of temperature in hibernation zones was -5.46-25.15^{o}C. Humidity in hibernation zones was 18.96-100% (recorded RH as high as 122.02%), with average humidity at all sites ranging from 65.43-100%. Data loggers reading humidity >100% should be assumed to be saturated: saturation results from prolonged exposure to humidity >95% (Maxim Integrated 2015).

Site 40 is a well-known recreational cave; however, it is very difficult to access during most of the hibernation season. Although a permit is legally required to enter the cave, no physical barrier exists to prevent entrance to the hibernation zone. Approximately 6 m before the interior limit of the hibernation zone, a gate has been installed to prevent vandalism to the extensive cave system. This gate is locked year-round, but a key may be loaned to experienced cavers. During the most recent survey in December 2014, only 2 bats were found roosting beyond the gate, suggesting that the hibernacula is afforded little protection by the gate. This site is primarily a Townsend's big-eared bat hibernation site. This site was visited in the summer of 2015, outside of the maternity season, to collect data loggers. Temperatures in the hibernation zone are similar to the outside environment on average, but the range of temperature is much smaller within the hibernation zone (Table 2, Figures 2 and 3). Data loggers at Site 40 recorded the only sub-zero temperatures within the hibernation zone of any site studied. It should be noted that data loggers at this site were placed significantly lower in the cave than roosting bats in most cases, roughly 1.5-3 m above the ground, while bats roost on the ceiling 3-12 m above the cave floor. However, the "before crawl" data logger is both central to the hibernation zone and closer to the level of roosting bats, as the ceiling in this part of the cave descends to 3-4.5 m above the cave floor and the data logger was placed approximately 2.5 m above the cave floor. The "before crawl" data logger never recorded a temperature below freezing (Table 2, Figure 2). The humidity within the hibernation zone varied less than the outside environment, with the humidity in the first room varying less than the exterior, but following a similar pattern (Figure 3). The "before crawl" and "big fissure" locations were similar in their humidity values and trends, as both showed gradual increases throughout the spring, summer, and fall before retrieval (Table 2, Figure 3). This pattern and the average temperatures within the hibernation zone are similar to previous years (Beard 2015).

Site 71 is a moderately popular recreational cave. While it has a gate, it has not been reliably locked during the hibernation season. Site 71 is a hibernacula for little brown myotis, western small-footed myotis, long-eared myotis, and Townsend's big-eared bats. As a large amount of data were lost because of stolen or malfunctioning data loggers, we visited this site in early October to place data loggers and lock the gate for the hibernation season. Although this should have fallen well before hibernation season, 21 bats were observed in the cave. The early arrival of a relatively large number of bats prior to hibernation could indicate a swarming site; future survey efforts will explore this further. One data logger was retrieved from the interior end of the hibernation zone. This data logger recorded a nearly constant temperature (Table 3, Figure 4). It became saturated shortly after placement and recorded a steadily constant humidity >100% until it was removed from the cave, at which point the humidity reading returned immediately to realistic levels, indicating that the data logger was functioning normally (Figure 5).

Site 121 is a cave with a gate that is locked year-round, although the public is allowed limited access through a permit system. We did not survey for hibernating bats during the time-frame of this report, but Townsend's big-eared bats are historically the only species known to hibernate at this site. Only 1 data logger was retrieved from the cave's interior, which was located deeper than the area where hibernating bats have been observed in the past. However, this site has been altered with explosives to remove an overhead hazard, and current bat use is unknown. Variation in both temperature and humidity resembled exterior data loggers from other sites; however, both external data loggers malfunctioned, so no direct comparison is possible (Table 4, Figures 6 and 7).

Site 133 is accessed through private land and visited with permission from the landowner. The interior of this site is known to be used by the landowner and guests. This cave is un-gated. Little brown myotis, western small-footed myotis, big brown bats, and Townsend's big-eared bats have been found hibernating at this site during previous surveys. We collected data loggers from this site in the summer of 2015, outside of the maternity season. No bats were seen during this visit. The cave environment at this site is considerably more stable, both in temperature and humidity, than the surface conditions at the entrance (Table 5, Figures 8 and 9). The interior of this cave maintains a very high humidity year-round (Figure 9).

Site 392 has some recreational use, although access is difficult during the hibernation season. This cave is un-gated. We visited this site during the summer of 2015, outside of the maternity season. No bats were observed, and the roost loggers had been removed, either by humans or by the bushy-tailed wood rats (*Neotoma cinerea*) that are prevalent at this site.

Hibernation surveys and swabbing

In the winter of 2015-2016, 11 mine adits, 1 concrete bunker, 1 artificial roost, and 6 natural caves were surveyed for the presence of hibernating bats; all survey results are shown in Table 1. In total, 55 hibernating bats were found, including 31 Townsend's big-eared bats, 23 western small footed myotis, and a single big brown bat.

Five mine adits were surveyed at the request of the Abandoned Mine Lands Program to help evaluate the need for bat friendly closures at these sites. In 4 of these adits (Sites 439,599,602, and 601), we found hibernating Townsend's big-eared bats; the 5th adit (Site 614) had no bats present (Table 1). None of these adits had previously been evaluated for use by bats.

Two artificial roosts were surveyed. Site 554 is a purpose-built artificial roost; no bats were present. Site 600 is an abandoned concrete bunker that had never been surveyed. It had 20 hibernating western small-footed bats and 1 hibernating big brown bat present (Table 1).

Of the 6 natural caves surveyed, 2 had bats present (Sites 61 and 122), both of which were previously known hibernacula. Both had Townsend's big-eared bats; Site 122 had western-small footed myotis, as well (Table 1). Two caves that had never previously had a winter survey were found to be unsuitable as hibernacula: Site 29 because of very low interior temperatures, and Site 65 because it was full of ice.

We were unable to survey 4 caves and a mine drainage tunnel. Two caves could not be located based on the GPS locations (Sites 94 and 60), 1 cave could not be reached with available equipment (Site 448), and the remaining cave was deemed unsafe due to sulfurous gas (Site 43). We were unable to survey Site 225, a mine drainage tunnel, because the entrance was locked with a key location unknown to either the Department or the landowner. Upon visual inspection, we judged it to be in an unstable condition, making entry unadvisable.

We sampled for *P. destructans* at Site 122; results were negative. Six caves, each in a different county, have been tested in the 3 years since the effort began; all have been negative for the fungus (Figure 1).

DISCUSSION

Although there are variations between caves, temperature and humidity data for most caves consistently show a stable, humid interior environment. Temperatures recorded during this period were consistent with previous data from these caves. With a range of 4.73-9.44^{o}C, average temperatures in the hibernation zone for all sites were lower than the optimal range for *P. destructans* growth (12.5-15.8^{o}C; Flory et al 2012). The total range of temperature in hibernation zones was much larger (-5.46-25.15^{o}C), with a large portion of the range falling within the optimal growth range for the fungus. Humidity in hibernation zones was 18.96-100%, with average humidity at all sites ranging from 65.43-100%. In many cases, data loggers placed in cave interiors recorded relative humidity >100% for long periods of time. Humidity readings >100% can be considered to be between 95% and 100% due to saturation error, and any average humidity calculations are biased (Maxim Integrated 2015). In light of these temperature and humidity levels in Wyoming's hibernacula and the most recent findings on the persistence of *P. destructans* under various conditions, we cannot conclude that environmental conditions in Wyoming caves are unsuitable for growth and persistence of the fungus.

We found that conditions in hibernacula may be suitable for the growth of *P. destructans,* but we cannot predict the effect its arrival will have on bats in Wyoming for several important reasons. First, most of the bats observed during this study behave differently than bats in WNS-affected areas, in that they do not cluster to hibernate or do not hibernate in large numbers, both of which can affect infection rates among individuals (Langwig et al. 2012). In fact, only 1 hibernacula (Site 71) monitored during this project has recorded *Myotis* spp. roosting in clusters >2 bats, but very little data were collected in the part of the hibernacula where myotis have been observed roosting. Second, both direct observation and models have suggested that microclimates used during hibernation may affect bat survival once caves are infected, so exposure to the fungus is not the only risk factor for mortality due to WNS (Boyles and Willis 2010, Flory et al. 2012, Hayman et al. 2016). Finally, even though we did observe western small-footed myotis in several locations, no other myotis species were detected. In most of the hibernacula, Townsend's big-eared bat (*C. Townsendii*) and western small-footed myotis (*M. ciliolabrum*) were the only bats present. No little brown myotis were observed within the hibernation season this year, despite their prevalence during summer surveys. Little brown myotis in Alaska have been documented using ground roosts with entrances only a few inches high as hibernacula, so it is possible that little brown bats in Wyoming are choosing habitat other than caves or mines to hibernate in, as well (K. Blejwas, personal communication). In order to truly understand the conditions under which Wyoming's little brown myotis hibernate and to predict the effect that WNS will have on this species, it is important to first locate the habitat that the majority of Wyoming's population uses during the winter.

One cave (Site 122) was tested for *P. destructans*. Environmental samples were taken in addition to the swabs taken from bats. Although environmental samples are not thought to be as good for early detection of *P. destructans* as samples from bats (A. Ballman, personal communication), the negative results in the southeastern corner of the state are encouraging, as these caves represent the closest sites to the current known extent of *P. destructans*. The negative *P. destructans* test result, in addition to the lack of any signs of WNS or abnormal mortality of hibernating bats reported in the state, supports the national surveillance team's assertion that Wyoming is still free of WNS (USFWS 2016).

Systematic monitoring of bat populations in the state is important for the effective implementation of management responses to all conservation threats to bats, including WNS.

Early detection of *P. destructans* will trigger a prearranged set of responses designed to mitigate the effects of WNS to hibernating bats (Abel and Grenier, 2012a). Both the monitoring of bat populations and the early detection of *P. destructans* are confounded by the fact that Wyoming's bats do not conform to expected patterns of behavior established by studying eastern populations. Current tests for *P. destructans* increase in effectiveness when 25 bats are tested, but very few of Wyoming's hibernacula host that many individuals. Large congregations of myotis have not been found in the state, which complicates any effort to monitor the population by making hibernacula counts alone insufficient as a monitoring method for the population as a whole. Our ability to predict the threat posed by WNS and to respond to any threat to bats is limited by our understanding of their year-round habitat use. Future work should concentrate on locating and quantifying critical roosting habitat of myotis species in Wyoming in order to monitor and mitigate the effect of WNS and other threats to the bat population.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Abel, B. L., and M. B. Grenier. 2012a. A strategic plan for white-nose syndrome in Wyoming. Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. 2012b. Inventories of forest bats in southeastern Wyoming: acoustic surveys. Pages 125-154 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. 2012c. Inventories of forest bats in southeastern Wyoming: mist netting. Pages 125-154 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Beard, L. O. 2015. Surveillance of hibernating bats and environmental conditions at caves and abandoned mines in Wyoming. Pages 163-194 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona and C. K. Rudd, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Boyles, J. G., and C. Willis. 2010. Could localized warm areas inside cold caves reduce mortality of hibernating bats affected by white-nose syndrome? Frontiers in Ecology and the Environment 8:92-98.

Coleman, J. T. H., and J. D. Reichard. 2014. Bat white-nose syndrome in 2014: a brief assessment seven years after discovery of a virulent fungal pathogen in North America. Outlooks on Pest Management 25:374-377.

Cudworth, N. L., S. Johnson, and M. B. Grenier. 2011. Inventories of forest bats in northeastern Wyoming: mistnetting. Pages 119-145 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (M. Grenier, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Filipi, T., M. B. Grenier, S. Chrisman, and E. Hannelly. 2009. Forest bat inventories completion report. Pages 123-135 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Flory, A. R., S. Kumar, T. J. Stohlgren, and P. M. Cryan. 2012. Environmental conditions associated with bat white-nose syndrome mortality in the north-eastern United States. Journal of Applied Ecology 49:680-689.

Hayman, D. T. S., J. R. C. Pulliam, J. C. Marshall, P. M. Cryan, and C. T. Webb. 2016. Environment, host, and fungal traits predict continental-scale white-nose syndrome in bats. Science Advances 2:e1500831.

Hoyt, J. R., K. E. Langwig, J. Okoniewski, W. F. Frick, W. B. Stone, and A. M. Kilpatrick. 2015. Long-term persistence of *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome, in the absence of bats. EcoHealth 12:330-333.

Johnson, S., and M. B. Grenier. 2010a. Forest bat inventories: Anabat acoustic surveys. Pages 145-161 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Johnson S., and M. B. Grenier. 2010b. Forest bat inventories: mistnetting. Pages 162-182 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Knudsen G. R., R. D. Dixon, and S. K. Amelon. 2013. Potential spread of white-nose syndrome of bats to the northwest: epidemiological considerations. Northwest Science 87:292-306.

Langwig, K. E., W. F. Frick, J. T. Bried, A. C. Hicks, T. H. Kunz, and A. M. Kilpatrick. 2012. Sociality, density-dependence, and microclimates determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome. Ecology Letters 15:1050-1057.

Maxim Integrated. 2015. Datasheet: DS1923 iButton hygrochron temperature/humidity logger with 8KB data-log memory. www.maximintegrated.com/en/products/comms.html (accessed 20 January 2015).

United States Fish and Wildlife Service [USFWS]. 2012. A national plan for assisting states, federal agencies, and tribes in managing white-nose syndrome in bats. National White-Nose Syndrome Decontamination Protocol – Version 06.25.2012.

United States Fish and Wildlife Service [USFWS]. 2016. White-nose syndrome: the devastating disease of hibernating bats in North America. www.whitenosesyndrome.org/resource/white-nose-syndrome-fact-sheet-march-2016 (accessed 9 March 2015).

United States Geological Survey [USGS] National Wildlife Health Center. 2013. Bat white-nose syndrome (WNS)/Pd surveillance submission guidelines. Appendix E: bat wing swab protocol.

United States Geological Survey [USGS] National Wildlife Health Center. 2015. Protocol for Fungal Skin Flora Project.

Verant, M. L., C. U. Meteyer, J. R. Speakman, P. M. Cryan, J. M. Lorch, and D. S. Blehert. 2014. White-nose syndrome initiates a cascade of physiological disturbances in the hibernating bat host. BMC Physiology 14:10.

Yandow, L., and L. O. Beard. 2015. Inventories of bats associated with cliff and canyon habitats in eastern Wyoming. Pages 133-162 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona and C. Rudd, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Yandow, L., and M. B. Grenier. 2013. Inventories of bats associated with cliff and canyon habitats in western Wyoming. Pages 234-265 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Yandow, L., and M. B. Grenier. 2014. Inventories of bats associated with cliff and canyon habitats in western Wyoming. Pages 253-284 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Table 1. Site number, type of roost, known hibernacula and hibernating species, species observed, and swabs taken for both *Pseudogymnoascus destructans* testing and native fungus identification during the most recent hibernacula survey at sites successfully surveyed from December 2015 – February 2016 in Wyoming. COTO = Townsend's big-eared bat (*Corynorhinus townsendii*); MYCI = western small-footed myotis (*Myotis ciliolabrum*); MYLU = little brown myotis (*M. lucifugus*); MYVO = long-legged myotis (*M. volans*); EPFU= big brown bat (*Eptesicus fuscus)*.

Site #	Site type	Previously recorded hibernacula (species)	Bats species (#)	*P. destructans* swabs	Native fungus swabs
442	Mine	Yes (COTO, EPFU)	0		
494	Cave	Yes (COTO, MYCI)	0		
445	Mine	Yes (COTO, MYEV, MYCI)	0		
446	Mine	Yes (MYCI)	0		
554	Artificial roost	No	0		
455	Mine	Yes (MYCI)	0		
69	Cave	No	0		
65	Cave	No previous winter survey	0		
29	Cave	No previous winter survey	0		
614	Mine	No previous winter survey	0		
439	Mine	No previous survey	COTO (13)		
599	Mine	No previous survey	COTO (1)		
444	Mine	Yes (COTO, EPFU, MYCI)	COTO (2)		1 COTO
602	Mine	No previous survey	COTO (2)		
122	Cave	Yes (COTO, EPFU, MYCI)	COTO (3), MYCI (2)	5 bat, 10 substrate	2 COTO, 1 MYCI
601	Mine	No previous survey	COTO (4)		
61	Cave	Yes (COTO, EPFU, MYCI, MYLU, MYVO)	COTO (9)		
443	Mine	Yes (COTO, MYCO, MYVO)	MYCI (1)		1 MYCI
600	Bunker	No previous survey	MYCI (20), EPFU (1)		

Table 2. Microclimate conditions at Site 40, including average, standard deviation (STD), and range of temperature (^{o}C) and relative humidity (%), at 2 exterior sites and 3 interior sites from 29 January to 14 September 2015. Data taken within the hibernation zone are in bold.

Site 40	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Ent 1	13.96	11.52	-16.05	47.61	52.34	25.57	5.13	104.59
Ent 2	13.75	11.00	-16.54	41.62	53.54	25.25	8.36	104.27
First Room	**7.93**	**5.38**	**-5.46**	**24.69**	**69.88**	**14.59**	**18.96**	**103.27**
Before Crawl	**5.24**	**1.56**	**4.09**	**25.15**	**69.47**	**10.04**	**19.40**	**84.09**
Big Fissure	**8.7**	**1.15**	**0**	**24.63**	**65.43**	**14.16**	**18.96**	**86.68**

Table 3. Microclimate conditions at Site 71, including average, standard deviation (STD), and range of temperature (^{o}C) and relative humidity (%), at 1 interior location from 23 February to 7 October 2015. Data taken within the hibernation zone are in bold.

Site 71	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Last Chamber	**5.22**	**0.24**	**5.02**	**5.53**	**117.55**	**3.01**	**109.73**	**122.02**

Table 4. Microclimate conditions at Site 121, including average, standard deviation (STD), and range of temperature (^{o}C) and relative humidity (%), at 1 interior site from 17 May 2014 to 16 September 2015. Data were taken from within the historical hibernation zone; however, current bat use of this cave is unknown.

Site 121	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Guano Room	10.17	9.92	-22.68	35.07	55.93	22.38	10.83	104.15

Table 5. Microclimate conditions at Site 133, including average, standard deviation (STD), and range of temperature (^{o}C) and relative humidity (%), at 2 exterior and 4 interior locations from 6 March to 18 August 2015. Data taken within the hibernation zone are in bold.

Site 133	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Ext 1	11.30	7.80	-5.50	37.60	63.63	24.61	9.76	105.63
Ext 2	11.72	7.65	-4.94	31.65	63.63	24.61	9.40	105.67
Portal	**9.44**	**4.10**	**4.09**	**20.63**	**83.76**	**18.72**	**27.02**	**107.58**
Start Climb					**101.50**	**1.49**	**97.20**	**103.50**
Breakdown	**4.73**	**0.25**	**4.56**	**6.57**	**98.25**	**0.10**	**95.05**	**100.30**
Drop	**4.84**	**0.26**	**4.07**	**5.07**	**95.68**	**0.92**	**94.01**	**98.42**

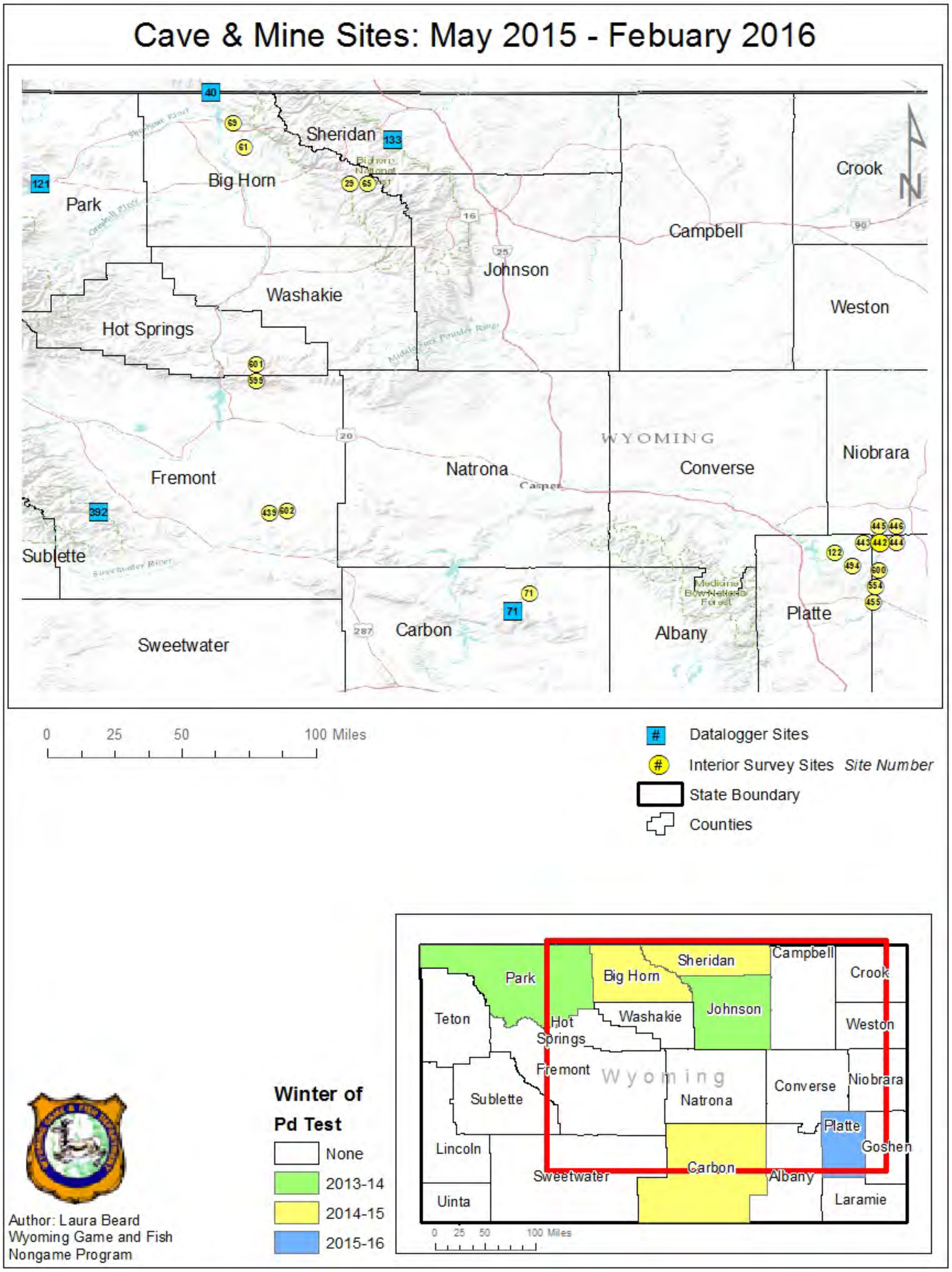

Figure 1. Cave and mines visited from May 2015 to February 2016 in Wyoming. Sites where interior surveys were completed in fall and winter are indicated by a yellow circle containing the Site number. Sites from which data loggers were collected are indicated by a blue square containing the Site number. Reference map shows counties tested for the presence of *Pseudogymnoascus destructans* (Pd), color coded by year; all tests have been negative.

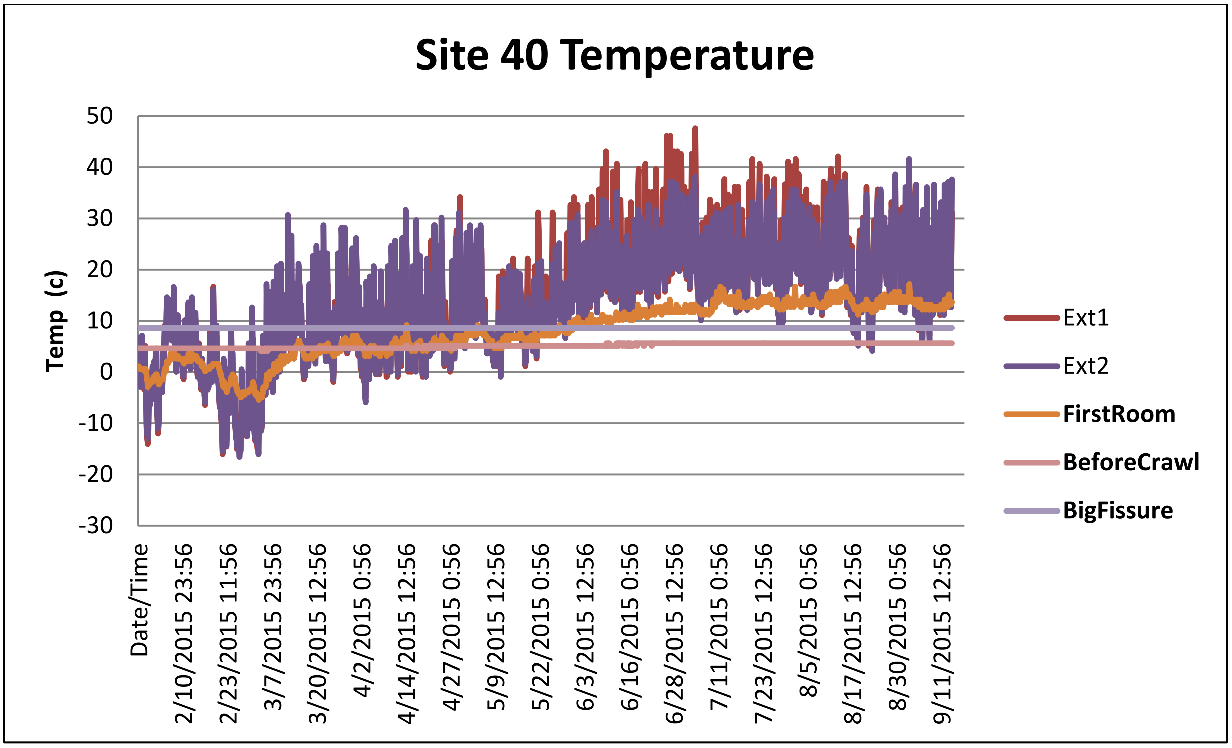

Figure 2. Temperature at Site 40 at 2 exterior and 3 interior locations from 29 January to 14 September 2015. Names of data loggers located within the hibernation zone are in bold.

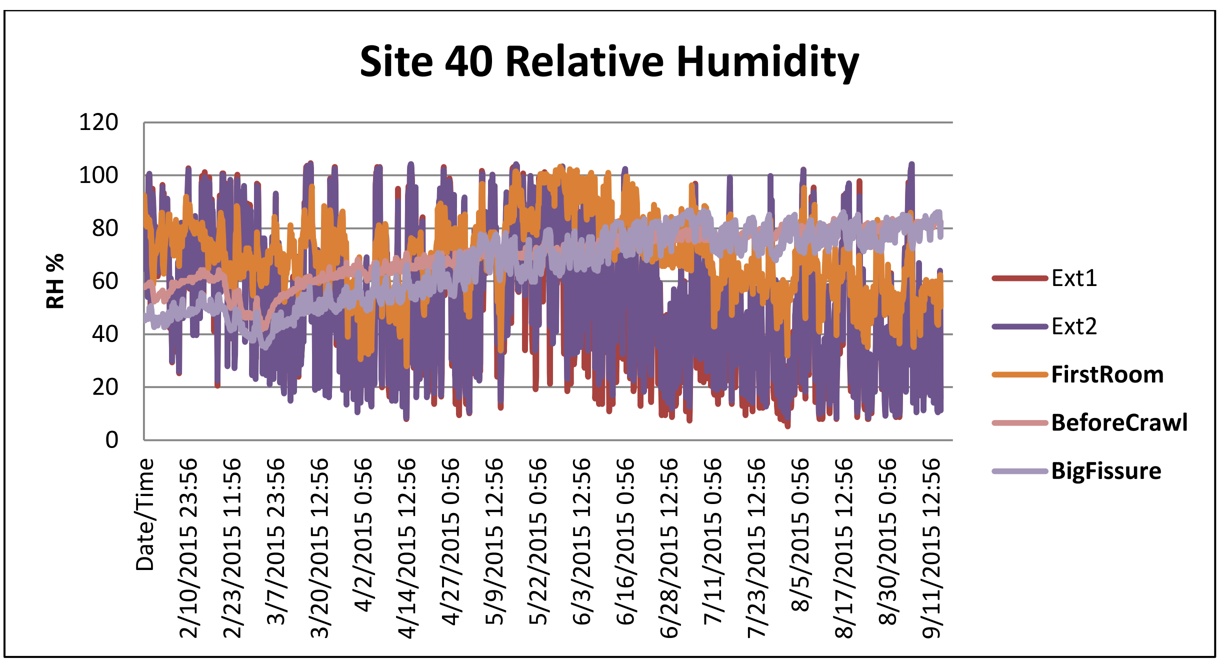

Figure 3. Relative humidity at Site 40 at 2 exterior and 3 interior locations from 29 January to 14 September 2015. Names of data loggers located within the hibernation zone are in bold.

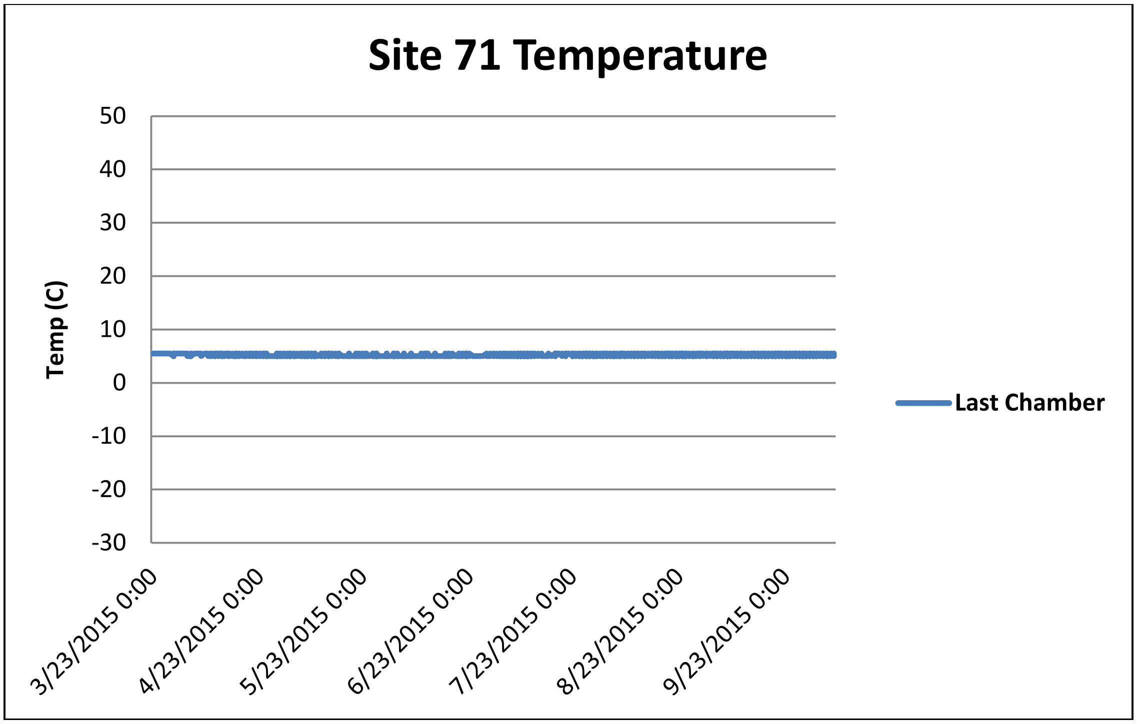

Figure 4. Temperature at Site 71 at 1 interior location from 23 March to 7 October 2015. This data logger was located at the back of the hibernation zone.

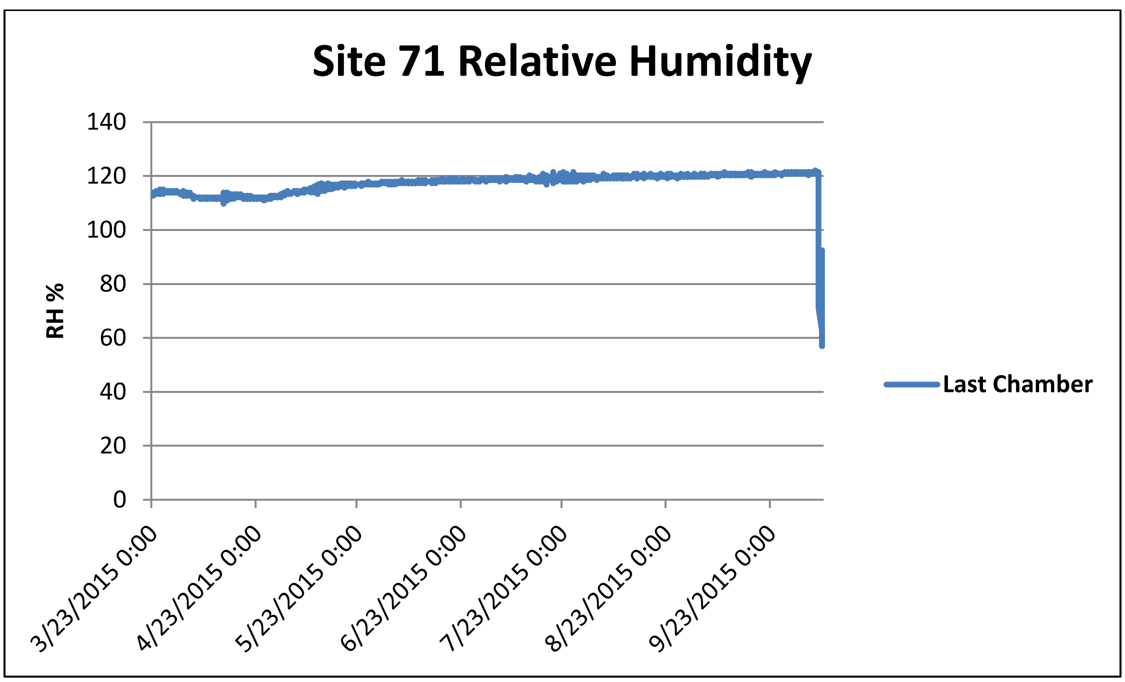

Figure 5. Relative humidity at Site 71 at 1 interior location from 23 March to 7 October 2015. The sharp decline in humidity corresponds to the removal of the data logger from the cave. This data logger was located at the back of the hibernation zone.

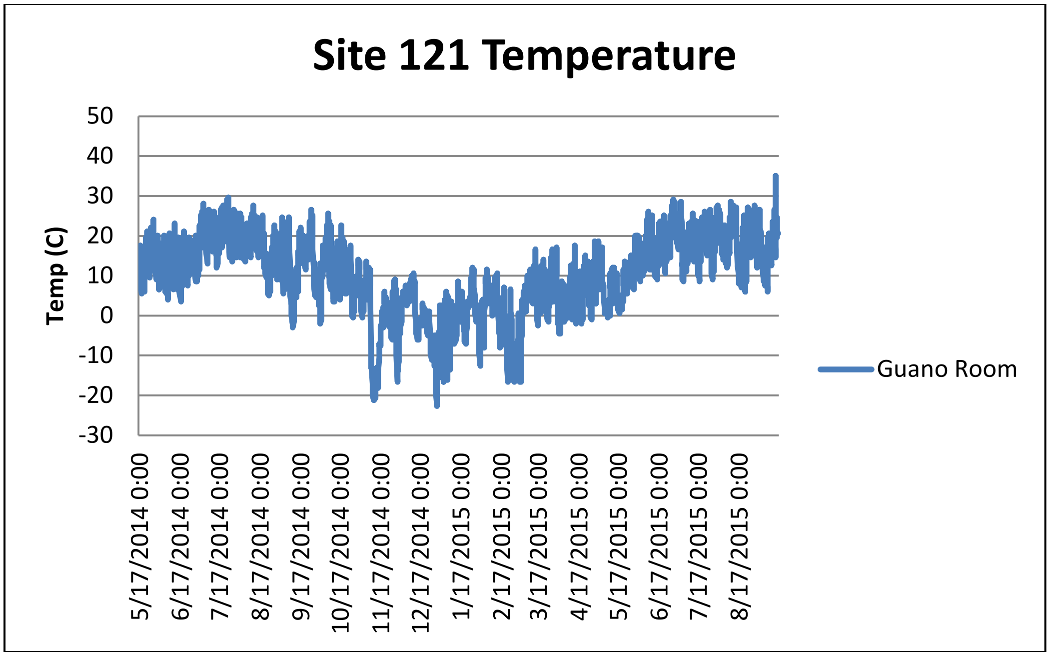

Figure 6. Temperature at Site 121 at 1 interior site from 17 May 2014 to 16 September 2015. This data logger was within the historical hibernation zone; however, the structure of the cave has since been changed by blasting to remove a hazard, and bat use of this cave is currently unknown.

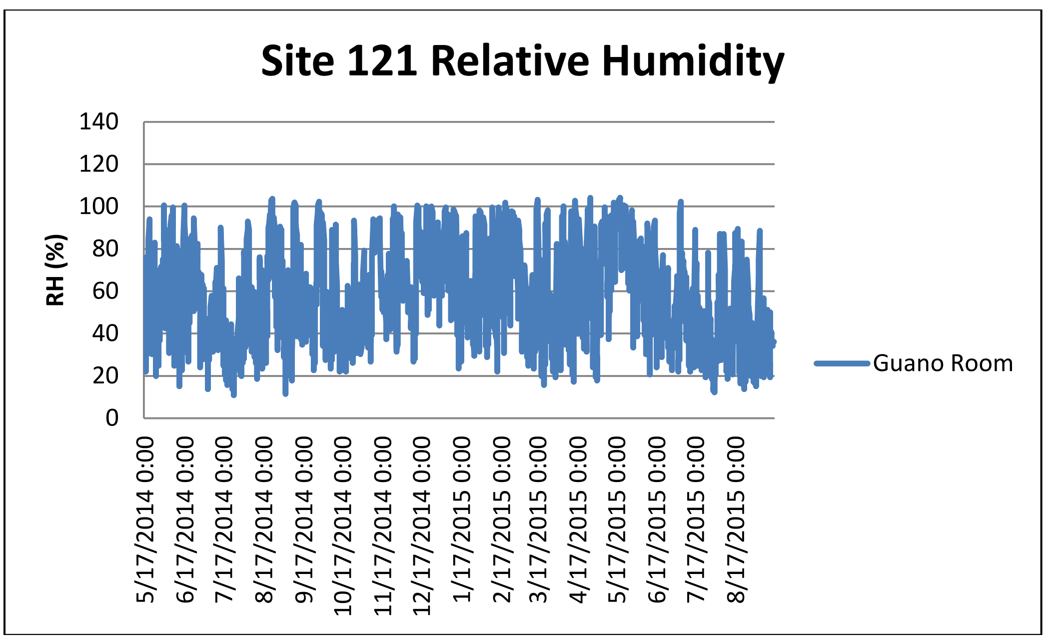

Figure 7. Relative humidity at Site 121 at 1 site from 17 May 2014 to 16 September 2015. This data logger was within the historical hibernation zone; however, the structure of the cave has since been changed by blasting to remove a hazard, and bat use of this cave is currently unknown.

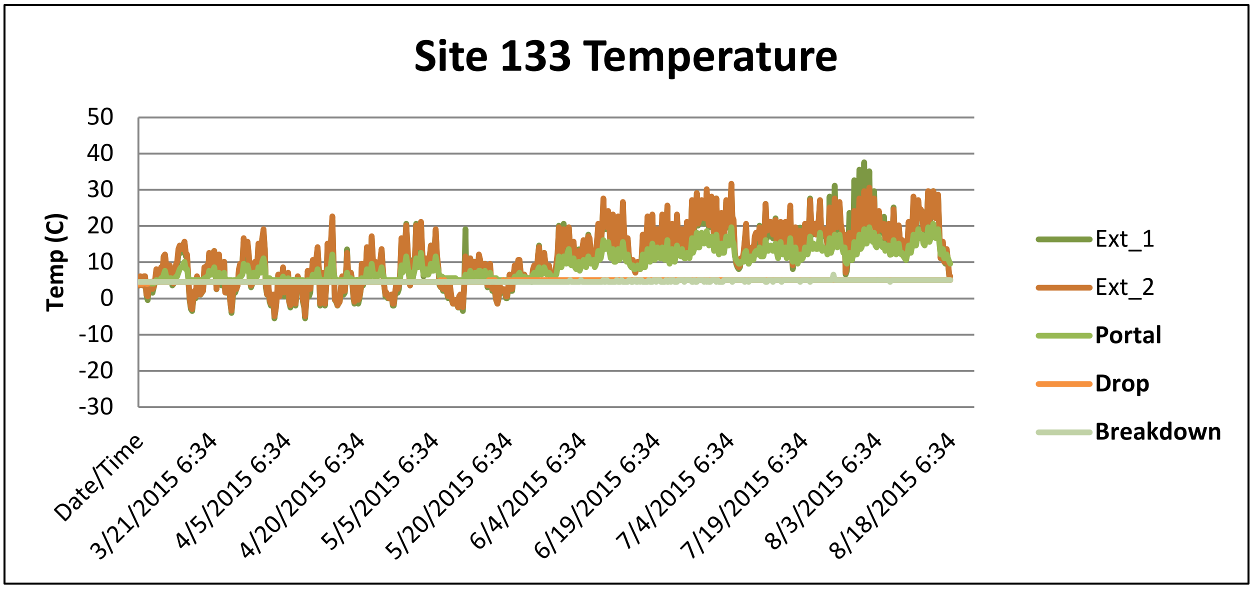

Figure 8. Temperature at Site 133 at 1 exterior and 3 interior locations from 6 March to 18 August 2015. Names of data loggers located within the hibernation zone are in bold.

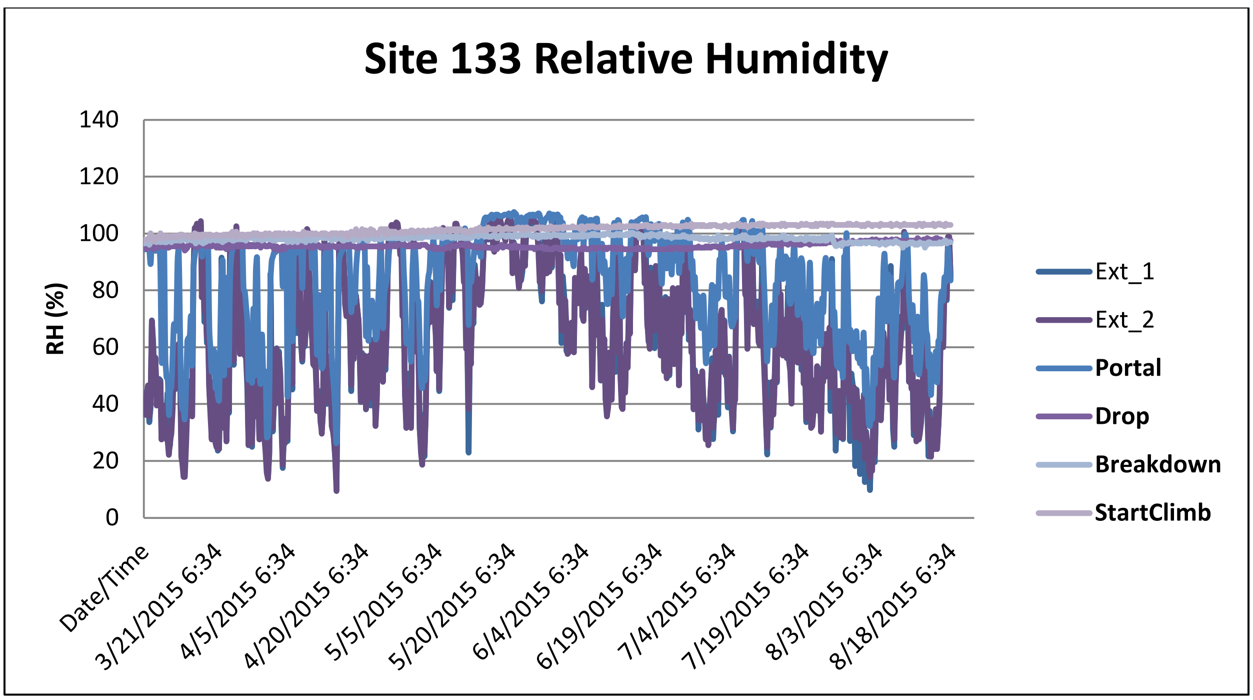

Figure 9. Relative humidity at Site 133 at 1 exterior and 3 interior locations from 6 March to 18 August 2015. Names of data loggers located within the hibernation zone are in bold.

INVENTORY OF BATS ASSOCIATED WITH CLIFF AND CANYON HABITATS OF EASTERN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2014 – 30 June 2016

PERIOD COVERED: 28 February 2015 – 31 March 2016

PREPARED BY: Laura Beard, Nongame Biologist

ABSTRACT

Wyoming's varied geology supports a landscape characterized by high ecological diversity. Features such as rock outcrops, cliffs, and canyons are important for many of the bat species found in the state. Many species depend on these habitats for roosting, foraging, rearing pups, and mating. Bats represent nearly 25% of all mammals classified as Species of Greatest Conservation Need in Wyoming. However, information about diversity, distribution, and abundance for bats associated with rocky habitats in Wyoming is lacking. This lack of data makes conservation and management in the face of large-scale disturbances (i.e., disease, climate change, and land-use changes) particularly challenging. We used capture and acoustic surveys to detect bats and assess distribution, reproductive status, and diversity across 36 survey grid cells. We captured 208 individuals, representing 8 species, most of which were adults. Over half of the bats we caught were female. More than half of the adult bats were reproductive. We detected 2 species of bats acoustically that we did not capture (*Antrozous pallidus* and *Corynorhinus townsendii*). The most commonly captured and detected species was the little brown myotis (*Myotis lucifugus*), which accounted for 2/3 of all captures, as well as 42% of acoustic detections. The high proportion of female little brown myotis in our capture data resulted from 1 site with an exceedingly high capture rate, likely due to the proximity of critical roosting habitat. Capture rates for the remaining sites were low when compared to this site, as well as many sites in the previous survey year. This difference in capture rates demonstrates the importance of high quality locations for bat conservation. This survey resulted in 9 reproductive and distributional updates for bats in Wyoming, and provides a baseline with which to monitor future changes in distribution of bat species. This survey completes an 8-year statewide survey effort for bats in Wyoming. Data from this inventory will be combined with survey data from previous years to provide a robust and detailed picture of bat distribution across Wyoming, which will help prioritize management efforts in response to large-scale disturbances.

INTRODUCTION

Globally, bats occupy a broad range of niches and a variety of habitats; however, all of Wyoming's bat species are insectivorous. Wyoming's bats impact many species of insect prey, making them important to both agriculture and ecosystem health. In the US as a whole, bats consume tons of insects annually. This predation redistributes nutrients and provides a natural biological control of herbivorous insect pests (Duchamp et al. 2010). The economic value of bats that forage on herbivorous insects is estimated to be worth $3.7 billion per year to the continental US agricultural sector (Boyles et al. 2011). As the economic effect due to insect population control by bats in forests and rangeland has not been established, it is likely that the services provided by bats are actually substantially greater than is known. Because bats have important ecological and economic impacts, the investigation and conservation of these species is essential for maintaining the health and functionality of Wyoming's diverse ecosystems.

Bats are particularly sensitive to large-scale disturbances due to several life history traits (Jones et al. 2009). They have low reproductive rates and are long-lived for animals of similar body size (Racey and Entwistle 2000). Many species require specific and uncommon habitat features or environments. For example, some bats roost in caves and abandoned mines and often select areas with specific temperature and humidity profiles within each site (Davis 1970, Whitaker and Gummer 1992, Webb et al. 1996). These characteristics make bats particularly vulnerable to declines associated with anthropogenic impacts or diseases.

One of the primary threats to bats in North America is white-nose syndrome (WNS), which is a disease caused by the fungus *Pseudogymnoascus desctructans*. WNS has caused drastic declines in eastern populations of some cave and mine dwelling bats since its outbreak in New York in 2006 (Blehert et al. 2008; Cryan et al. 2010). The death toll of bats as of January 2012 was around 6 million individuals (USFWS 2012). WNS has steadily progressed westward through natural and anthropogenic transmission, and was most recently confirmed in eastern Nebraska in November 2015 (USFWS 2015b). Physiological and distributional limitations of the fungus are unknown in the western US and Canada. Consequently, the pace and certainty of the spread of the fungus is yet to be determined. Differences in the roosting ecology of bats, as well as the resilience of the fungus in alternative climates, will determine the vulnerability of populations in the western US. Population declines in the East and fear that the disease will spread across the continent has led to recent petitions to list 2 species of bats that are residents in Wyoming under the Endangered Species Act (ESA). On 2 April 2015, the northern long-eared myotis (*Myotis septentrionalis*) was listed as Threatened under the ESA (USFWS 2015a). The status of the little brown myotis (*M. lucifugus*) remains unresolved in the US. In Canada, both myotis species, as well as the American perimyotis (*Perimyotis subflavus*), also called the tricolored bat, have been listed as federally Threatened, largely due to population declines caused by WNS (Environment Canada 2015).

While risk of WNS is currently the most apparent threat to bats in North America, other large-scale disturbances, such as climate change and wind energy development, also have the potential to negatively impact bat populations (Arnett et al. 2008). Change in climate has the potential to influence several aspects of the ecology of bats. For temperate insectivorous species, timing of emergence from hibernation, parturition, roost selection, foraging behavior, and distribution all have the potential to be affected by climate change (Ransome and McOwat 1994, Christe et al. 2001, Adams and Hayes 2008, Rebelo et al. 2010, Sherwin et al. 2013). Furthermore, interactions of climate change with other large-scale disturbances (e.g., wind energy development) may create synergistic effects and confound the outcome of individual disturbances. Information on diversity and distribution of bats in Wyoming will enhance our ability to respond effectively to these emerging issues.

In Wyoming, 18 bat species are known to occur, 13 of which are considered Species of Greatest Conservation Need (SGCN; WGFD 2010, Orabona et al. 2012). Many of these bats use cliff and canyon habitats for important activities such as roosting, foraging, hibernating, and rearing offspring, making these habitats important for gaining information about bat diversity, distribution, and abundance. Our objective for the 2015 field season was to use mist nets and acoustic detectors to collect data on distribution, reproductive status, and diversity of bats that occurred in cliff and canyon habitats in eastern Wyoming. We have completed the final year of the 2-year inventory, and we report results here from that survey effort.

METHODS

We selected survey sites differently in this inventory than in the western cliff and canyon bat inventory. In previous surveys, workers mapped desired attributes, laid the 100 km^2 per grid cell bat survey grid over the map, and randomly selected grid cells for trapping. In the eastern half of Wyoming, there is less public land and insufficient large, rocky features on the landscape for modeling of this habitat type to be useful. We relied on remote sensing to identify potential survey sites and ground-truthing for the final site selection for both years of inventories. We selected netting and acoustic survey sites by choosing areas that: 1) were accessible by survey personnel; 2) consisted of habitat characteristics and resource availability that would increase the likelihood of having bat activity (i.e., water, potential roosts, flyways); 3) were among or adjacent to cliff or canyon habitat; and 4) were suitable for setting up mist nets and/or acoustic detectors. We avoided trapping in grids that were trapped as part of the previous year of this survey or the Forest Bat Inventory.

In most grid cells, we trapped only one site. At each site, we used a combination of mist nets (Avinet, Inc., Dryden, NY) and acoustic detectors (Song Meter SM2BAT, Wildlife Acoustics, Inc., Concord, MA) to maximize the likelihood of detecting all species present at a survey site. We conducted mist net surveys for bats at 30 sites, located within 29 distinct grid cells; 2 trapping locations were within the same grid cell. At all of these sites, we deployed a detector close to the nets. On 29 of the capture nights, we deployed a 2nd detector at a distance from the trap site to gather additional acoustic information. Most of these additional acoustic sites were within the same grid cell as the capture site, but in 3 instances the detector was placed outside of the trapping grid cell. In one instance, no trapping was done, but 2 grid cells were sampled with acoustic equipment.

At each survey site, we used a GPS (GPSMap 62S, Garmin International, Inc. Olathe, KS) to record location and elevation. We also characterized vegetation, rock features, distance to nearest water, and the type of water features present. We used a Kestrel weather station

(Kestrel Meter 3500 Weather Meter, Kestrelmeters.com Birmingham, MI) to record weather conditions, including temperature, barometric pressure, wind, and relative humidity at the beginning and end of each survey. Cloud cover was estimated visually.

Capture Surveys

We used mist nets to capture bats and investigate bat activity, diversity, reproductive status, and morphology. We chose mist net configurations to optimize capture potential by using a combination of single high (2.6-m) or triple high (7.8-m) nets with varying lengths (2.6, 6, 9, 12, and 18 m) at each netting site. The number, size, and placement of nets depended on local topography and habitat characteristics, such as water flow rate, water depth, vegetation, and other local features. We opened the mist nets ≤30 minutes after sunset and kept them open for 3 hours unless our survey was truncated because of weather (Abel and Grenier 2013). When a new species was captured within the last 30 minutes of a survey, we kept nets open until 30 minutes after the time of capture (Abel and Grenier 2013).

We checked nets every 10-15 minutes and removed captured bats from the nets as quickly as possible. We put each captured bat into a cloth bag for processing. We used techniques outlined by Abel and Grenier (2013) to record species, sex, reproductive status, and age. We used the Dichotomous Key to Bats of Wyoming (Hester and Grenier 2005) to identify species. Early in the season (i.e., during June and early July), we gently palpated the lower abdominal area to check for pregnancy. We also assessed female reproductive status by looking for evidence of current or post-lactation. Females bearing young have large, hard, and hairless nipples, while females without young have hairy and inconspicuous nipples. Males were classified as reproductive if testes were descended and swollen. We classified each bat as adult or juvenile by illuminating the wing and examining the epiphyseal plates for ossification. We also measured forearm length and ear length and determined wing damage score according to Reichard and Kunz (2009). We followed the National White-Nose Syndrome Decontamination Protocol – Version 06.25.2012 (WNS Executive Committee 2012) and decontaminated equipment at the end of each survey.

To summarize capture data, we counted the number of captures for each site and calculated the approximate number of net meter hours by multiplying the length of nets used during a survey by the number of survey hours. We calculated captures per unit effort for each grid by dividing the number of captures by net meter hours, and multiplied by 100 to provide an index of bat activity. We also calculated species diversity for each grid. We report mean (±SE) for all data.

Acoustic Surveys

We deployed detectors near ponds, lakes, streams, rivers, rocky outcrops, cliffs, and potential flyways where we expected high bat activity. Two acoustic detectors were placed each trap night, one near the netting site and another at a distance. The microphone was positioned 2 m above the ground. We programmed detectors to start recording at sunset, and record for 4 hours.

For acoustic analysis, we used the Sonobat Batch Attributer utility to attribute metadata to the existing call files, and Sonobat Batch Scrubber 3 to remove noise files. Calls of good quality resulted in classification from Sonobatch with discriminate probability >0.90. We followed the mean classification as classified by Sonobat, unless manual classification was warranted. We manually classified all call files that Sonobat identified as any species uncommon to Wyoming. We also manually classified calls when the program identified a species that had not been previously detected in a particular area. For call files classified by Sonobat as 40kHz calls with no species level identification, we manually classified calls to determine species. Several of these calls were removed because they were of poor quality or clearly showed two distinct bat calls in the same file. After any necessary manual classification, we calculated the number of classified files per survey hour as an index of activity and the number of species detected for species diversity, and report all data as mean (± SE).

RESULTS

In 2015, we surveyed sites located within the eastern part of Wyoming, which we defined as the 15 counties on the eastern side of the state (Figure 1). A majority of sites were within 1 km of cliff and canyon habitat and were comprised of xeric shrubland, sagebrush, or mixed-grass prairie habitats. Mean (± SE) elevation of sites was 1,926.4 m (± 58.7 m).

Capture Surveys

We primarily netted over open water, including ephemeral and permanent streams and rivers, reservoirs, and small ponds. At the 30 sites that we mist netted in 2015, we captured 208 bats representing 8 different species (Table 1; Figure 2). We used 51.1 net meters (± 5.3 m) per survey, with a survey length of 2.9 hours (± 0.1 hours). We captured 7.2 individuals (± 18.8; range = 0-104; Figure 2) per survey night. The capture rate for the season was 2.6 (± 1.4) bats per hour. We did not record morphometric measurements for 61 captured bats because of extremely high capture rates and the need to release bats quickly. The little brown myotis (66.3%) was the most commonly captured species, followed by western small-footed myotis (*M. ciliolabrum*; 7.7%). The long-eared myotis (*M. evotis*) and the big brown bat (*Eptesicus fuscus*) each accounted for 7.2% of captures. The remaining species each comprised <3% of all captures and included the long-legged myotis (*M. volans*), hoary bat (*Lasiurus cinereus*), and silver-haired bat (*Lasionycteris noctivagans*). Figures 5-14 show locations of captures for each species.

Of the 208 bats captured in 2015, 57.7% were female, 40.9% were male, and 1.4% of bats escaped before sex could be determined (Table 2). Adults comprised 95.7% of all captures, while 2.4% were identified as juveniles, and the remaining 1.9% were released without determining age (Table 2). Approximately 61.7% of captured female bats were reproductive, 46.7% of captured females were lactating, and 8.7% were obviously pregnant; 33% of captured males were reproductive. In 1.4% of captures, reproductive status was not determined (Table 2). It is worth noting that exactly half of the bats captured in the 2015 cliff and canyon survey effort were captured on a single survey night. At one site, 104 bats were captured; 102 (98.1%) of these were little brown myotis. Of these, 71 (69.6%) were female, 47 (66.2 % of female little brown myotis captured) of which were lactating. Overall, 5 bats had noticeable physical wing damage, such as tears or excessive pinpricks in the membrane; however, we detected no evidence of damage from WNS. Captures contributed to 5 updates in the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012; Table 3).

Acoustic Surveys

We conducted acoustic surveys at 62 locations, with recording times of 4.0 (± 0.2) hours per site. Recording time per grid cell was 6.9 (± 1.8) hours, with 36 grid cells sampled. Ten resident species were detected acoustically, including 2 that were not captured this season, pallid bat (*Antrozous pallidus*) and Townsend's big-eared bat (*Corynorhinus townsendii*). We recorded 1,830 classifiable calls in 2015 (Table 1).

The little brown myotis (42.3%) was the most frequently detected species, followed by the western small-footed myotis (19.6%), the big brown bat (17.0%) and the silver-haired bat (11.6%). The hoary bat (4.3%) and the long-eared myotis (4.8%) were detected less frequently, while all other species, long-legged myotis, fringed myotis (*M. thysanodes*), pallid bat, and Townsend's big-eared bat, each accounted for <1% of detections. Figures 5-14 show locations where we detected each species with acoustic equipment. Acoustic detections contributed to 4 status updates in the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al.; Table 3).

DISCUSSION

During the final year of this 2-year inventory project, we successfully detected 10 species classified as residents, 3 of which are summer residents only, and 8 of which are SGCN. By targeting cliff and canyon habitats in the eastern portion of the state, we were able to collect information about bats in habitat types that were underrepresented in previous inventory efforts (e.g., forest bat inventory 2008-2011; western cliff and canyon bat inventory 2012-2013[Filipi et al. 2009; Johnson and Grenier 2010a, b; Cudworth et al. 2011, Abel and Grenier 2012a, b; Yandow and Grenier 2013, 2014; Yandow and Beard 2015]). The cliff and canyon inventory will be the single largest survey effort for bats in this habitat type and will contribute significantly to the conservation and management of bats in Wyoming.

During the 2015 inventory, we captured fewer bats than in the previous inventory year, although capture efforts and study areas were very similar. This is likely due to the extent of the available survey sites: most trappable sites adjacent to large cliff faces or in extensive canyons had been previously surveyed, leaving a choice of small canyons and short cliffs. Half of all bats captured in 2015 were captured on a single survey night, and the high proportion of lactating female little brown myotis at this capture site indicates the proximity of a large little brown myotis maternity roost or a cluster of roosts. Maternity roosts are critical roosting habitat, as the roosts and their specific characteristics are important to the lifecycle of the bats that use them. This survey site was located on a section of river that is designated as a National Wildlife Refuge and was surrounded by large, open tracts of ranch land with many large rock outcrops. This site is a good example of extensive rocky habitat and may illustrate the importance of such areas for bat conservation. This single capture event is responsible for the high proportion of females and little brown myotis in our demographic data. This difference in captures and detections between sites is interesting and could be due solely to a congregation of bats at a maternity roost. Alternately, it could be an indication of a preference for large areas of suitable habitat, or that this site was located in better quality habitat than the majority of survey sites for this year.

Using a combination of capture and acoustic survey methods increased our likelihood of detecting all species that were present at a survey site, especially species that were difficult to capture. For a given site, we often detected a species via both methods (i.e., capture and acoustic). Occasionally, we captured species that we had failed to detect acoustically and vice versa. For example, we captured long-legged myotis at 5 sites, but at 4 of those sites we failed to detect this species acoustically. Conversely, we detected but did not capture a Townsend's big-eared bat and a pallid bat, which are rare and difficult to capture (O'Farrell and Gannon 1999). Thus, we believe that by combining acoustic and capture techniques, we are able to maximize the detections of species within each survey grid cell.

The 2015 inventory season was the last of 4 inventory years in which we surveyed bats in rocky habitat throughout the state. We have made considerable progress toward improving our understanding of the status and distributions of bat species associated with cliff and canyon habitats in Wyoming. This 4-year effort, combined with the previous 4 years of the forest bat inventory, gives us an excellent baseline of bat distribution in the state. As no long-term monitoring was done during this period, these data alone cannot be used to estimate population trends. To best complement this work, future research should focus on long-term population monitoring and land use patterns by bats in order to facilitate conservation of these important species.

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LITERATURE CITED

Abel, B. L., and M. B. Grenier. 2012a. Inventory of forest bats in southeastern Wyoming: mist netting. Pages 125-154 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. 2012b. Inventory of forest bats in southeastern Wyoming: acoustic surveys. Pages 125-154 *in* Threatened, Endangered, and Nongame Bird and

Mammal Investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. 2013. Nongame mammals: Bats. Pages 20.2-1-20.2-42 *in* Handbook of Biological Techniques, Fourth Edition (S. Tessmann, Editor). Wyoming Game and Fish Department, Cheyenne, USA.

Adams, R. A., and M. A. Hayes. 2008. Water availability and successful lactation by bats as related to climate change in arid regions of western North America. Journal of Animal Ecology 77:1115-1121.

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. J. Aaftab, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. J. O'Connell, M. D. Piorkowski, and R. D. Tankersley. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61-78.

Blehert, D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Berlowski-Zier, E. L. Buckles, and W. B. Stone. 2008. Bat white-nose syndrome: an emerging fungal pathogen? Science 323:227-228.

Boyles, J. G., P. M. Cryan, G. F. McCracken, and T. H. Kunz. 2011. Economic importance of bats in agriculture. Science 332:41-42.

Christe, P., A. Lugon, N. Perrin, and P. Vogel. 2001. Food availability dictates the timing of parturition in insectivorous mouse-eared bats. Oikos 95:105-111.

Cryan, P. M., C. U. Meteyer, J. G. Boyles, and D. S. Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology 8:135.

Cudworth, N. L., S. Johnson, and M. B. Grenier. 2011. Inventories of forest bats in northeastern Wyoming: mist netting. Pages 119-145 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (M. Grenier, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Davis, W. H. 1970. Hibernation: ecology and physiological ecology. Pages 265-300 *in* Biology of Bats (W.A. Wimsatt, Editor). Academic Press, NewYork, New York, USA.

Duchamp, J. E., D. W. Sparks, and R. K. Swihart. 2010. Exploring the 'nutrient hot spot' hypothesis at trees used by bats. Journal of Mammalogy 91:48-53.

Filipi, T., M. B. Grenier, S. Chrisman, and E. Hannelly. 2009. Forest bat inventories completion report. Pages 123-135 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Hester, S. G., and M. B. Grenier. 2005. A conservation plan for bats in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Johnson, S., and M. B. Grenier. 2010a. Forest bat: anabat acoustic surveys. Pages 145-161 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Johnson, S., and M. B. Grenier. 2010b. Forest bat inventories: mist netting. Pages 162-182 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Jones, G., D. S. Jacobs, T. H. Kunz, M. R. Willig, and P. A. Racey. 2009. Carpe noctem: the importance of bats as bioindicators. Endangered Species Research 8:93-115.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

O'Farrell, M. J., and W. L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80:24-30.

Racey, P. A., and A. C. Entwistle. 2000. Life-history and reproductive strategies of bats. Pages 363-414 *in* Reproductive biology of bats, (E.G. Crichton and P.H. Krutzch, Editors). Academic Press, San Diego, California, USA.

Ransome, R. D., and T. P. McOwat. 1994. Birth timing and population changes in greater horseshoe bat colonies (*Rhinolophus ferrumequinum*) are synchronized by climatic temperature. Zoological Journal of the Linnean Society 112:337-351.

Rebelo, H., P. Tarroso, and G. Jones. 2010. Predicted impact of climate change on European bats in relation to their biogeographic patterns. Global Change Ecology 16:561-576.

Reichard, J. D., and T. H. Kunz. 2009. White-nose syndrome inflicts lasting injuries to the wings of little brown Myotis (*Myotis lucifugus*). Acta Chiropterologica 11:457-464.

Sherwin, H. A., W. I. Montgomery, and M. G. Lundy. 2013. The impact and implications of climate change for bats. Mammal Review 43:171-182.

Environment Canada. 2015. Factsheet on the emergency listing order for the little brown myotis, the northern myotis and the tri-colored bat. Species at Risk Public Registry Office. www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=1372 (accessed 15 January 2016).

United States Fish and Wildlife Service [USFWS]. 2012. North American bat death toll exceeds 5.5 million from white-nose syndrome. News Release. www.fws.gov/ (accessed 15 September 2014).

United States Fish and Wildlife Service [USFWS]. 2015a. Endangered and threatened wildlife and plants; threatened species status for the northern long-eared bat with 4(d) rule, final rule and interim rule. Federal Register 80:17974-18032.

United States Fish and Wildlife Service [USFWS]. 2015b. Fungus that causes bat disease detected in Nebraska. WNS News. http://www.fws.gov/ (accessed 18 November 2015).

Webb, P. I., J. R. Speakman, and P. A. Racey. 1996. How hot is a hibernaculum? A review of the temperatures at which bats hibernate. Canadian Journal of Zoology 74:761-65.

Whitaker Jr., J. O., and S. L. Gummer. 1992. Hibernation of the big brown bat, *Eptesicus fuscus*, in buildings. Journal of Mammalogy 73:312-16.

White-Nose Syndrome Executive Committee [WNS]. 2012. National White-Nose Syndrome Decontamination Protocol – Version 06.25.2012. www.whitenosesyndrome.org/sites/default/files/resource/national_wns_revise_final_6.25.12.pdf (accessed 15 May 2013).

Wyoming Game and Fish Department. 2010. State Wildlife Action Plan. Wyoming Game and Fish Department, Cheyenne, USA. https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/SWAP/Wyoming-SGCN.pdf (accessed 19 January 2016).

Yandow, L., and M. B. Grenier. 2013. Inventories of Bat Associated with Cliff and Canyon Habitats in Western Wyoming. Pages 234-265 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Yandow, L., and M. B. Grenier. 2014. Inventories of Bat Associated with Cliff and Canyon Habitats in Western Wyoming. Pages 253-284 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Yandow, L., and L. O. Beard. 2015. Inventories of Bat Associated with Cliff and Canyon Habitats in Eastern Wyoming. Pages 133-162 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona and C. Rudd, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Table 1. Bat species that occur in Wyoming, with number captured during the 2015 survey (May-August). Status of residency for bats is represented with the following abbreviations: R = resident (year-round or seasonal), P = peripheral, A = accidental occurrence (as identified by Hester and Grenier 2005). Association with cliff and canyon identifies the ecology of each species in the context of cliff and canyon habitat: S = specialist of cliff and canyon in Wyoming; G = generalist, cliffs and canyons are important for this species in addition to other habitats; N = species is not expected to be associated with cliff and canyon habitats (Adams 2003). Native Species Status (NSS) for Species of Greatest Conservation Need for bats are 2, 3, 4, or U (WGFD 2010).

Scientific name (common name)	Resident status	Cliff and canyon assoc.	Native Species Status	Captures	Acoustic detections
Antrozous pallidus (Pallid bat)	R	S	NSS3	0	1
Corynorhinus townsendii (Townsend's big-eared bat)	R	S	NSS2	0	1
Eptesicus fuscus (Big brown bat)	R	G	NSS4	15	311
Euderma maculatum (Spotted bat)	R	S	NSS3	0	0
Lasionycteris noctivagans (Silver-haired bat)	R	N	-	6	213
Lasiurus cinereus (Hoary bat)	R	N	-	6	79
Myotis ciliolabrum (Western small-footed myotis)	R	S	NSS4	16	359
Lasiurus borealis (Eastern red bat)	P	N	NSSU	0	0
Myotis evotis (Long-eared myotis)	R	G	NSS3	15	87
Myotis lucifugus (Little brown myotis)	R	G	NSS4	139	774
Myotis septentrionalis (Northern long-eared myotis)	R	G	NSS3	0	0
Myotis thysanodes (Fringed myotis)	R	G	NSS3	1	2
Myotis volans (Long-legged myotis)	R	G	NSS3	5	3
Myotis californicus (California myotis)	P	G	-	0	0
Myotis yumanensis (Yuma myotis)	P	G	-	0	0
Tadarida brasiliensis (Brazilian free-tailed bat)	P	G	-	0	0
Nyctinomops macrotis (Big free-tailed bat)	A	G	-	0	0
Perimyotis subflavus (American perimyotis)[1]	A	G	-	0	0

[1] American perimyotis is also known as the tri-colored bat.

Table 2. Demographics of bats captured in eastern Wyoming, May-August 2015 (n = 208). Data are summarized by species. Undetermined (Und.) age, sex, and reproductive status indicate that the individual was released early or escaped the handler before measurements could be taken. Reproductive status is represented by the following abbreviations: R = Reproductive (males), L = Lactating, P = Pregnant, N = Non-reproductive.

Species	Sex			Age			Reproductive status				
	F	M	Und.	A	J	Und.	R	L	P	N	Und.
Eptesicus fuscus	4	10	1	13	1	1	6	0	4	4	1
Lasiurus cinereus	0	6	0	5	1	0	1	0	0	5	0
Lasionycteris noctivagans	2	4	0	3	3	0	2	0	1	3	0
Myotis ciliolabrum	10	5	1	15	0	1	2	3	2	8	1
Myotis evotis	6	9	0	15	0	0	6	1	0	8	0
Myotis lucifugus	91	48	0	138	0	1	29	49	10	51	0
Myotis thysanodes	1	0	0	1	0	1	0	0	1	0	0
Myotis volans	5	0	0	5	0	0	0	2	0	3	0
Myotis spp.	1	3	1	4	0	0	3	1	0	0	1
Percent of total captures (n = 208)	57.7	40.9	1.4	95.7	2.4	1.9	23.6	26.9	8.7	39.4	1.4

Table 3. Updates to the Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012) from surveys in eastern Wyoming, May-August 2015. Updates are presented by latilong, based on individuals captured and summarized by species. B = breeding, including dependent young, juvenile animals, lactating or post-lactating females; O = observed, but due to mobility of the species and lack of factors listed under "B", breeding cannot be assumed; b = animals were observed and, due to limited mobility, breeding is assumed; a = the species was detected with acoustic equipment and additional verification is warranted; __ = no verified records.

Species	Latilong degree block	Current status	Updated status
Lasiurus cinereus	12	O	B
Lasionycteris noctivagans	12	O	B
Myotis ciliolabrum	14	__	a
Myotis evotis	13,14	__	a
	25	a	O
Myotis lucifugus	13	O	B
Myotis thysanodes	25	a	B
Myotis volans	13	__	a

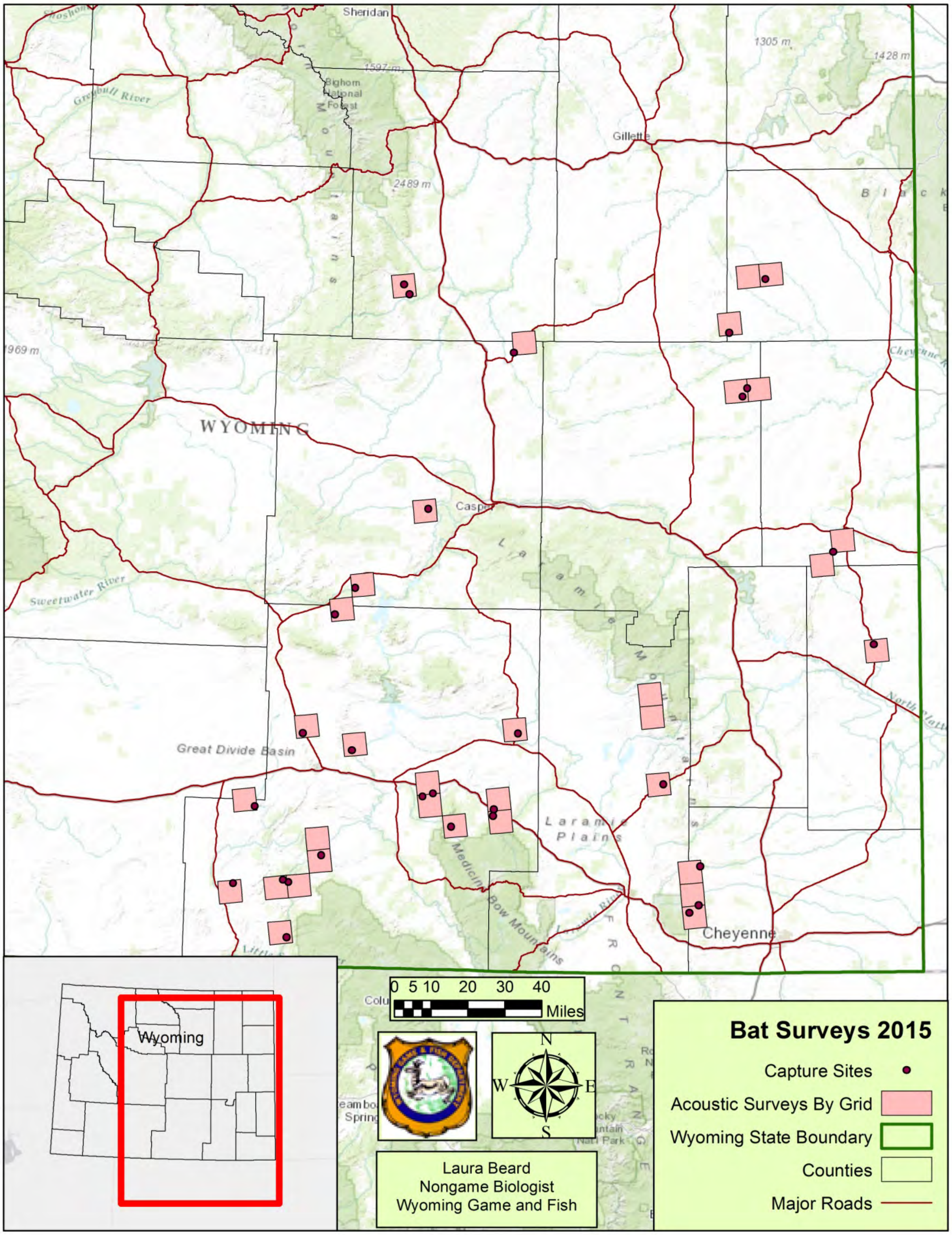


Figure 1. Study area with grid cells surveyed for bats in eastern Wyoming, May-August 2015. Capture sites are shown as points; grid cells surveyed acoustically are shown in pink.

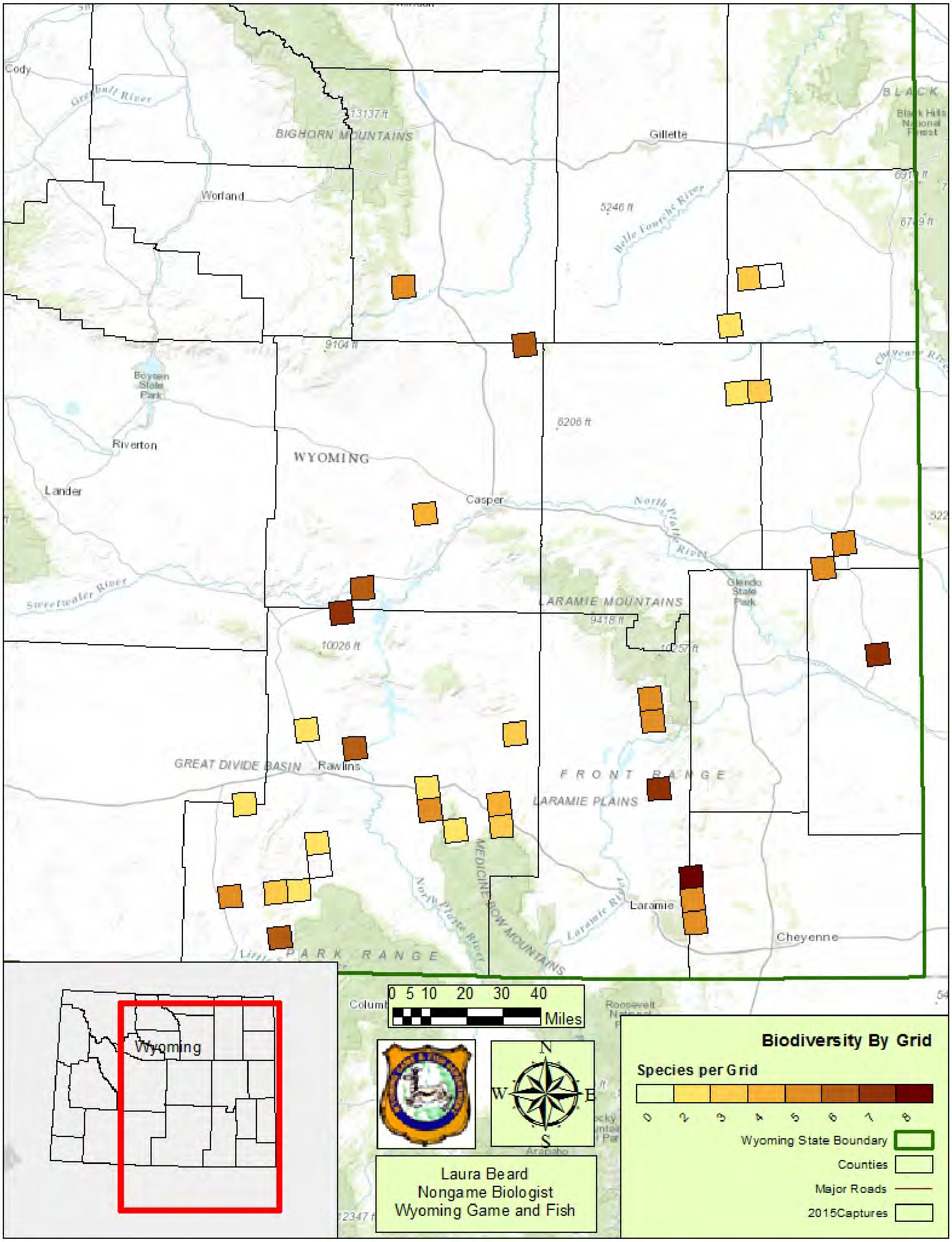


Figure 2. Location of grid cells surveyed throughout eastern Wyoming, May-August 2015. Colors correspond to the number of species of bats detected (acoustic and live-captures) within each grid cell surveyed.

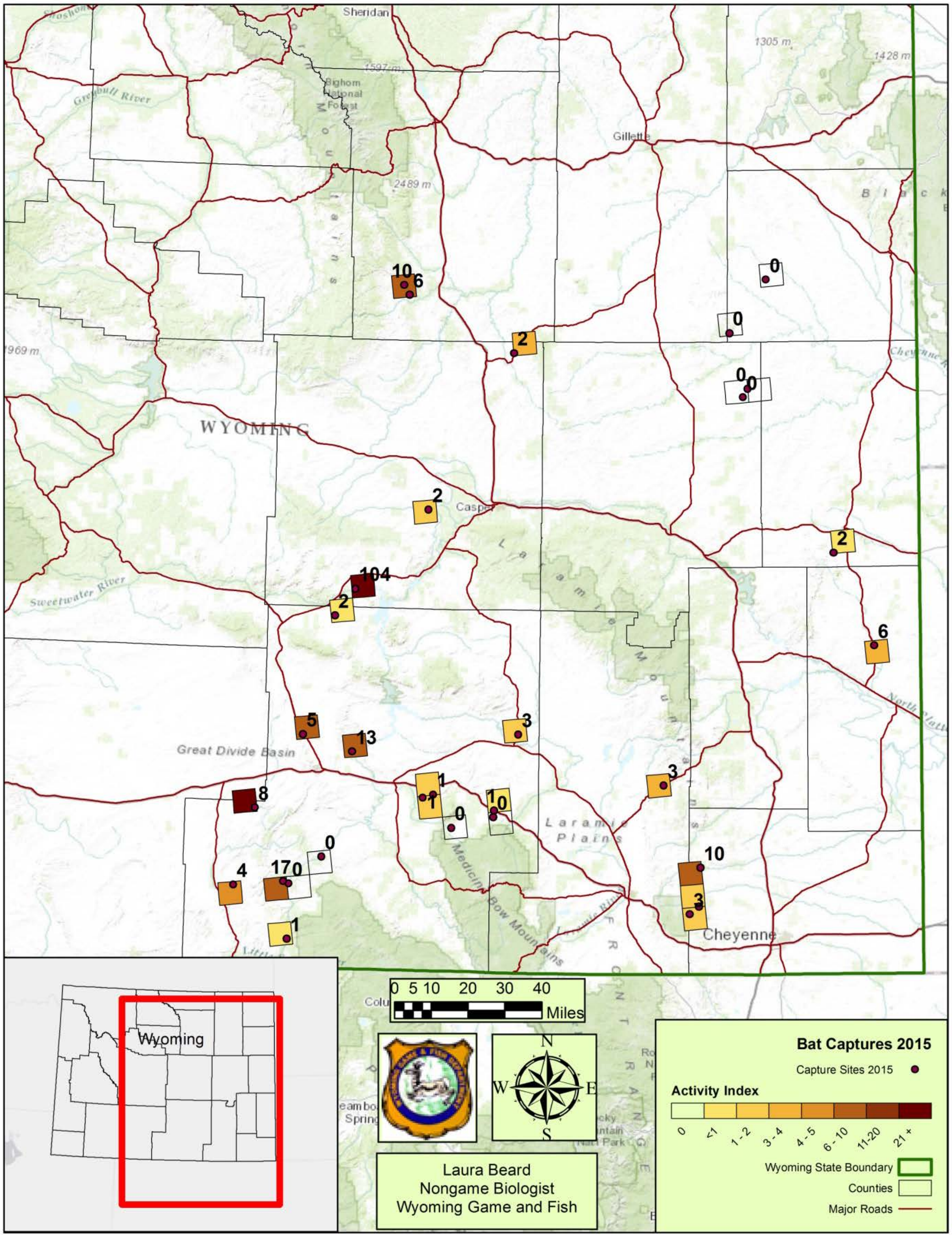


Figure 3. Location of grid cells surveyed by mist-netting throughout eastern Wyoming, May-August 2015. Captures per unit effort for each grid cell and individuals captured at each site are presented. Colors correspond to captures per unit effort. Labels represent the number of individuals captured per grid cell.

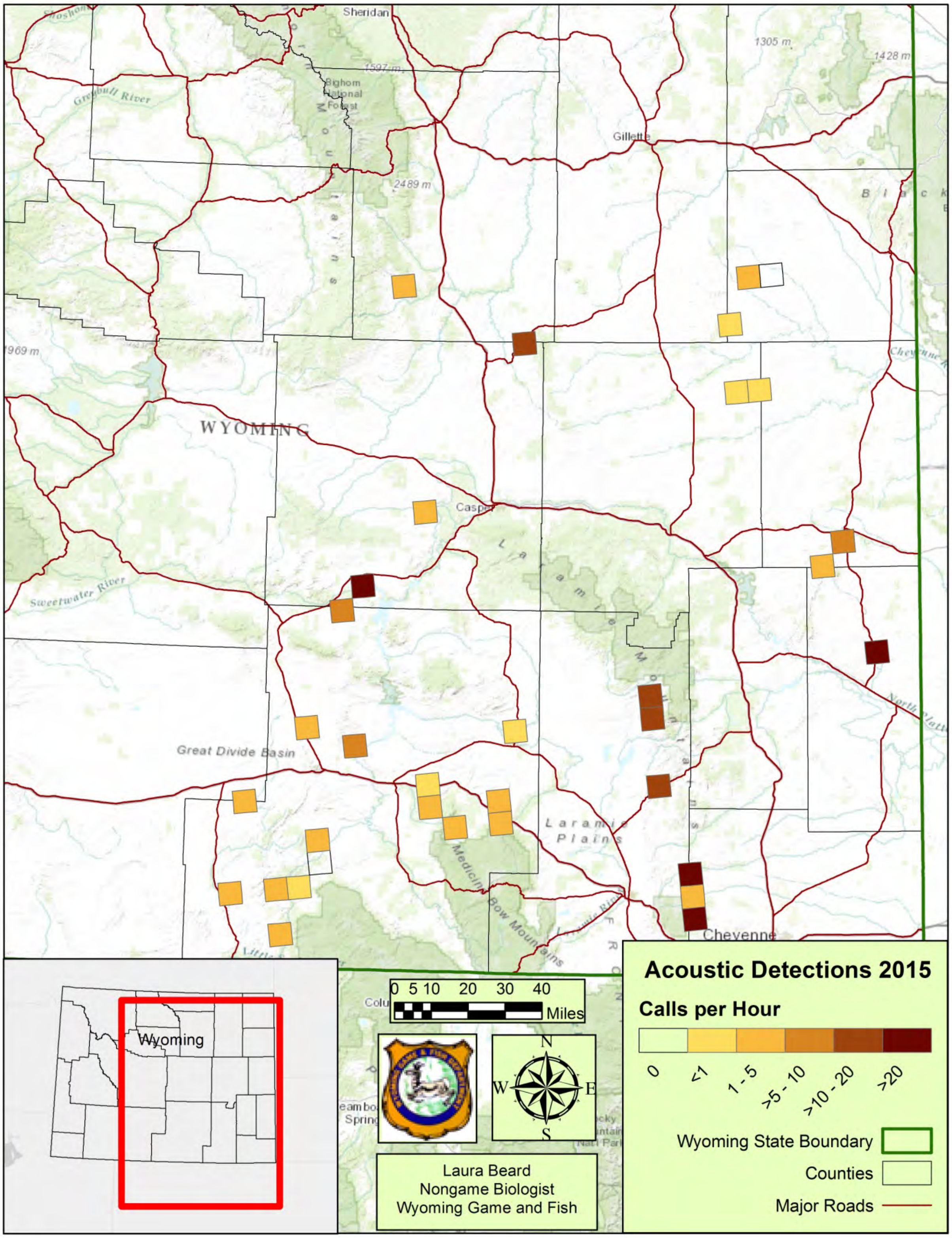


Figure 4. Location of grid cells surveyed acoustically throughout eastern Wyoming, May-August 2015. Colors correspond to classified calls per hour for each grid cell.

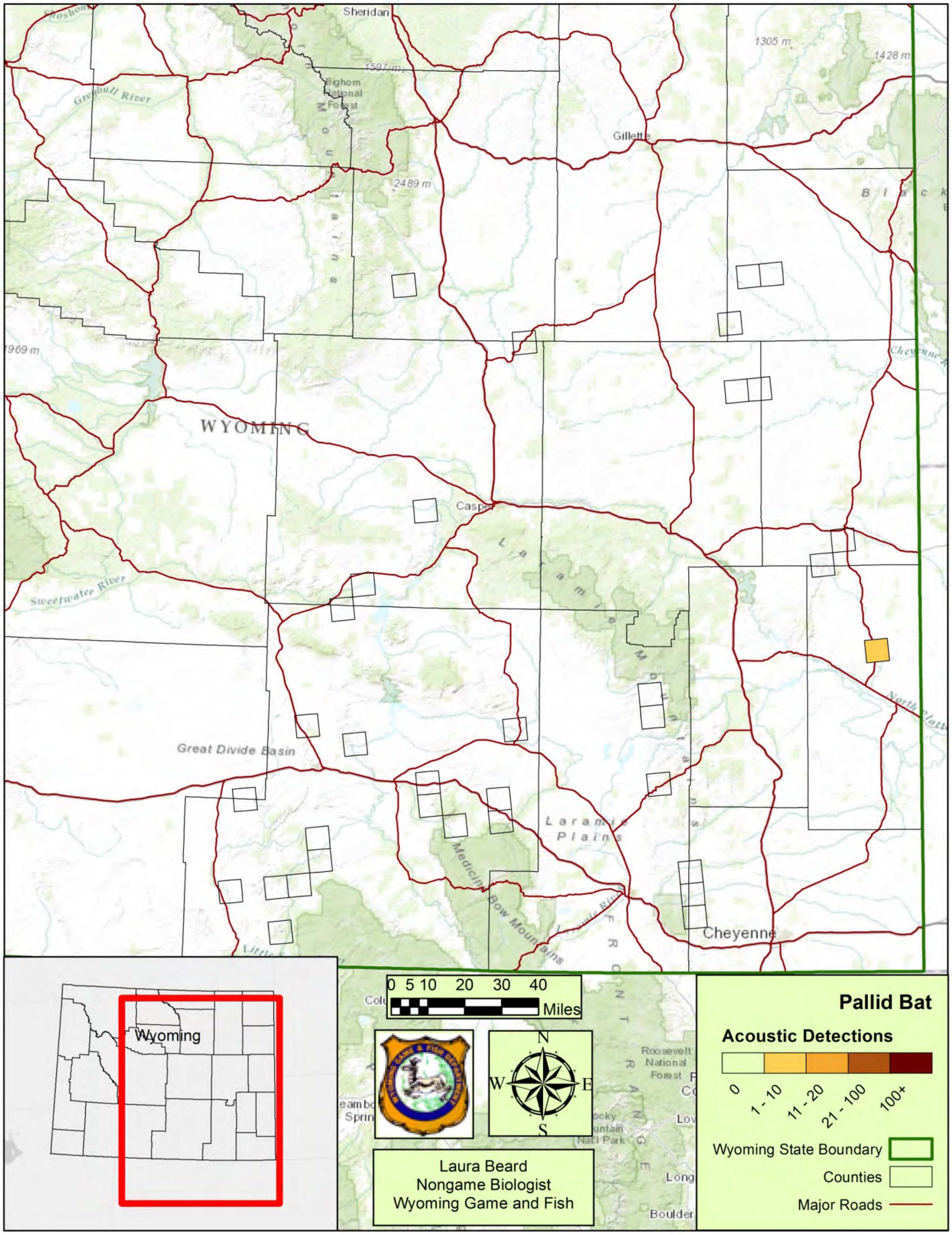


Figure 5. Grid cells in which pallid bats (*Antrozous pallidus*) were detected in eastern Wyoming, May-August 2015. Color of each grid cell corresponds to the number of classified call files.

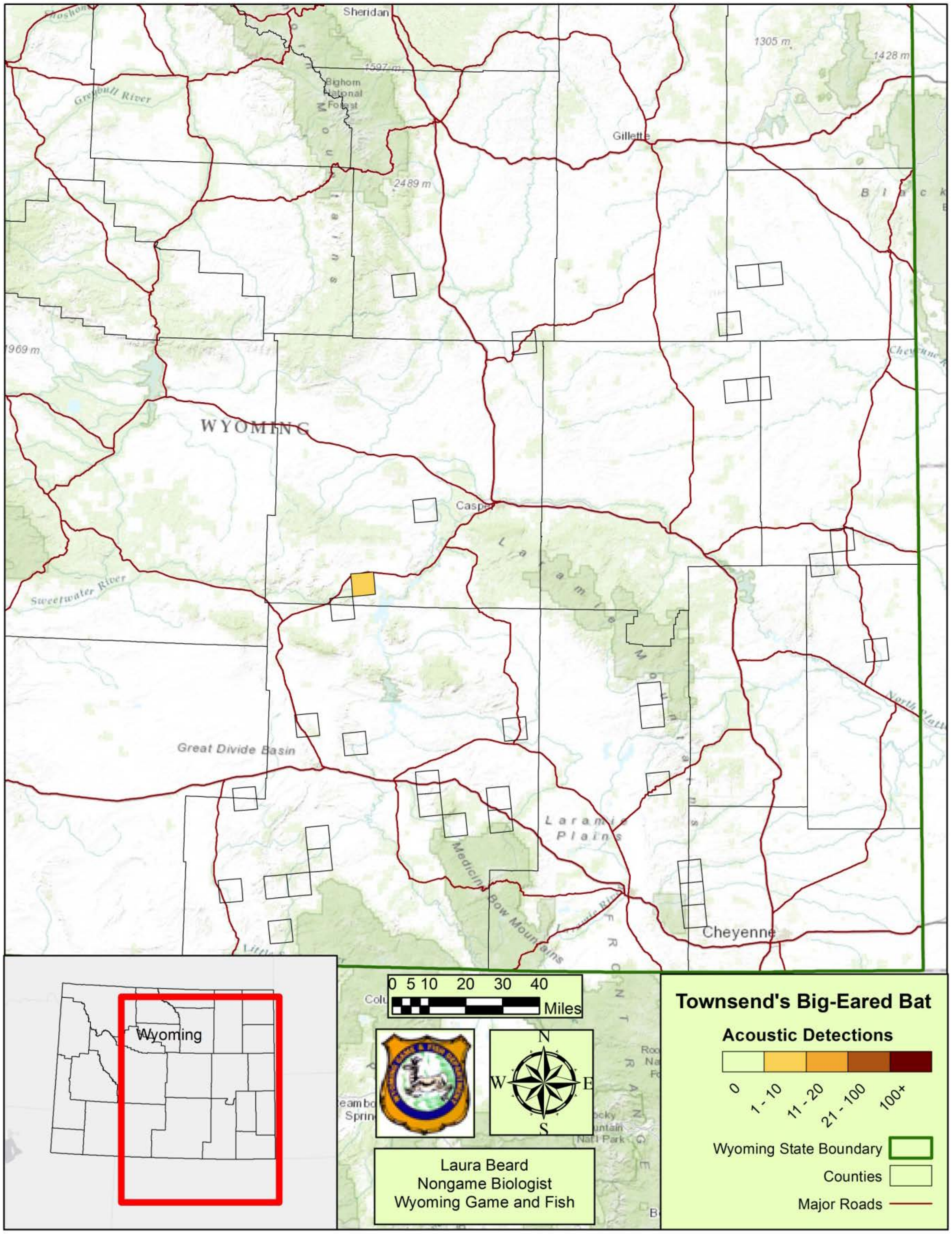


Figure 6. Grid cells in which Townsend's big-eared bats (*Corynorhinus townsendii*) were detected in eastern Wyoming, May-August 2015. Color of each grid cell corresponds to the number of classified call files.

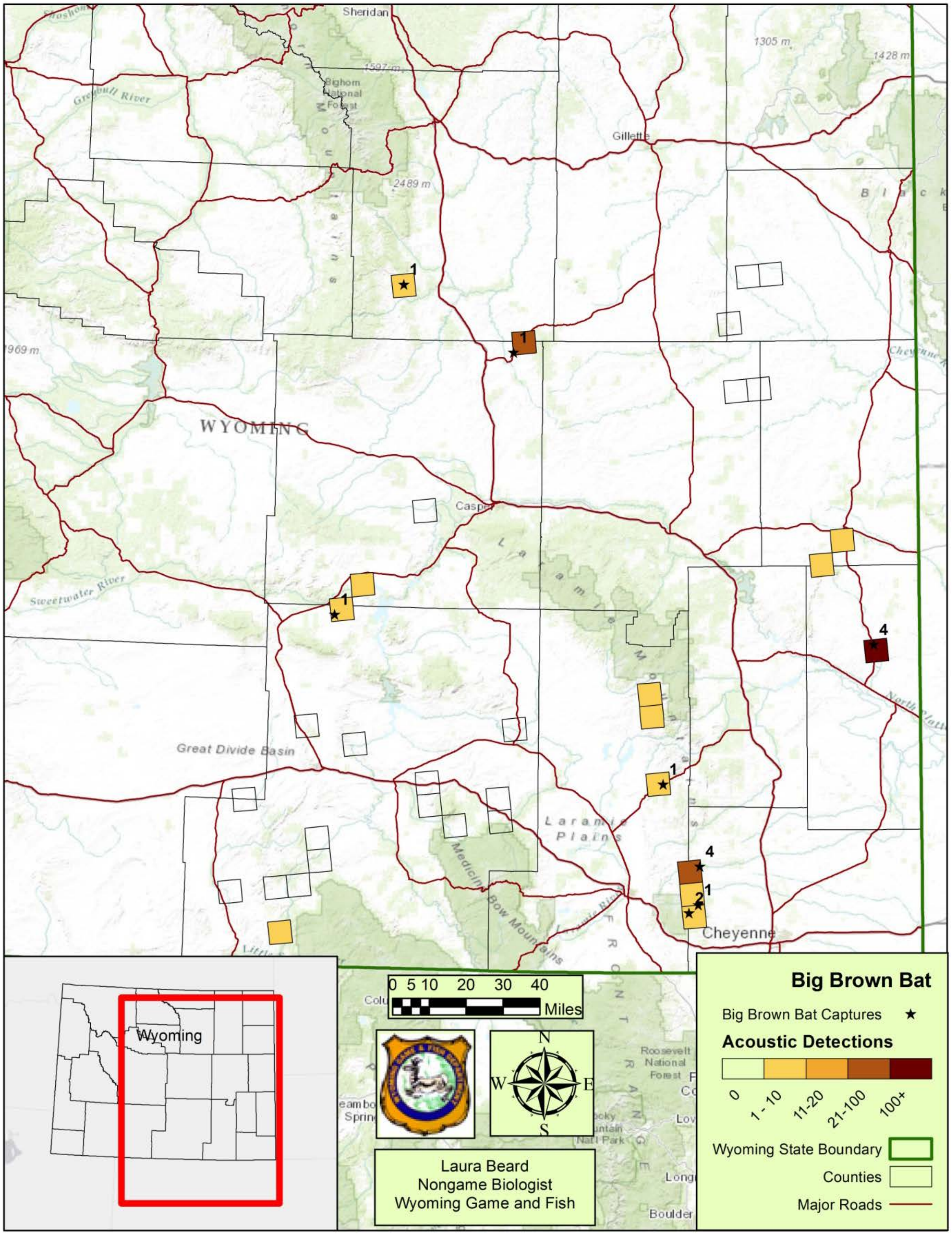


Figure 7. Locations where big brown bats (*Eptesicus fuscus*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

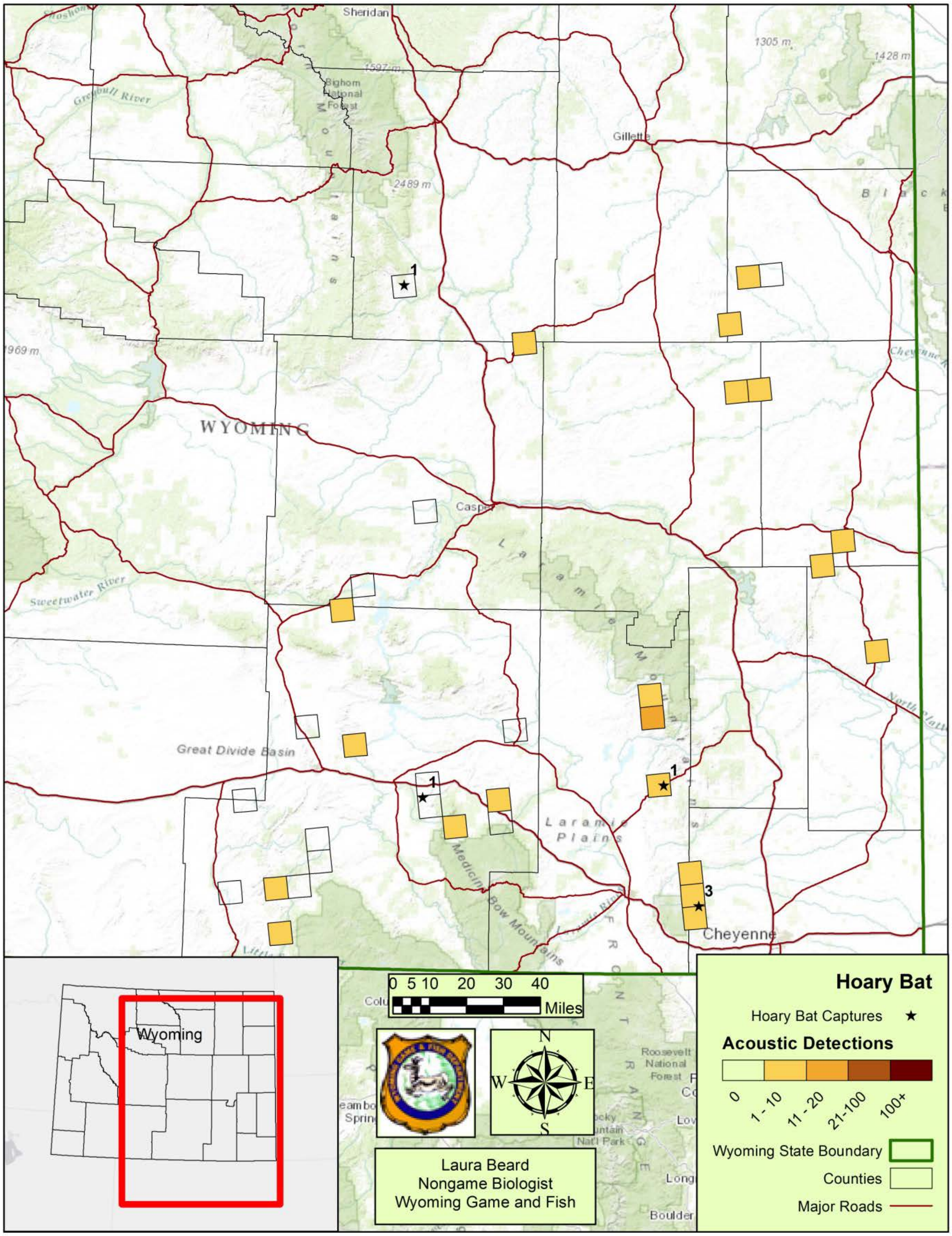


Figure 8. Locations where hoary bats (*Lasiurus cinereus*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

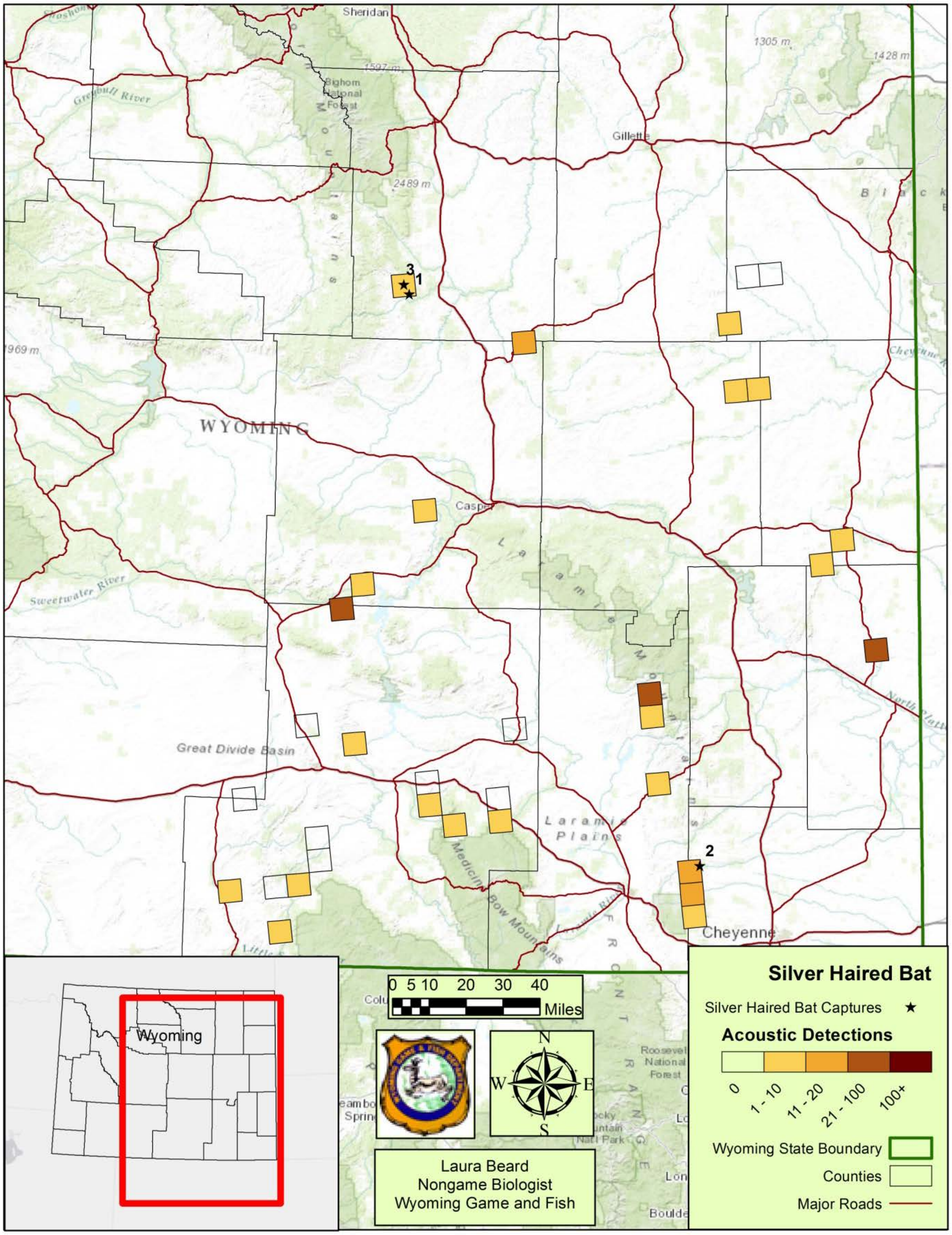


Figure 9. Locations where silver-haired bats (*Lasionycteris noctivagans*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

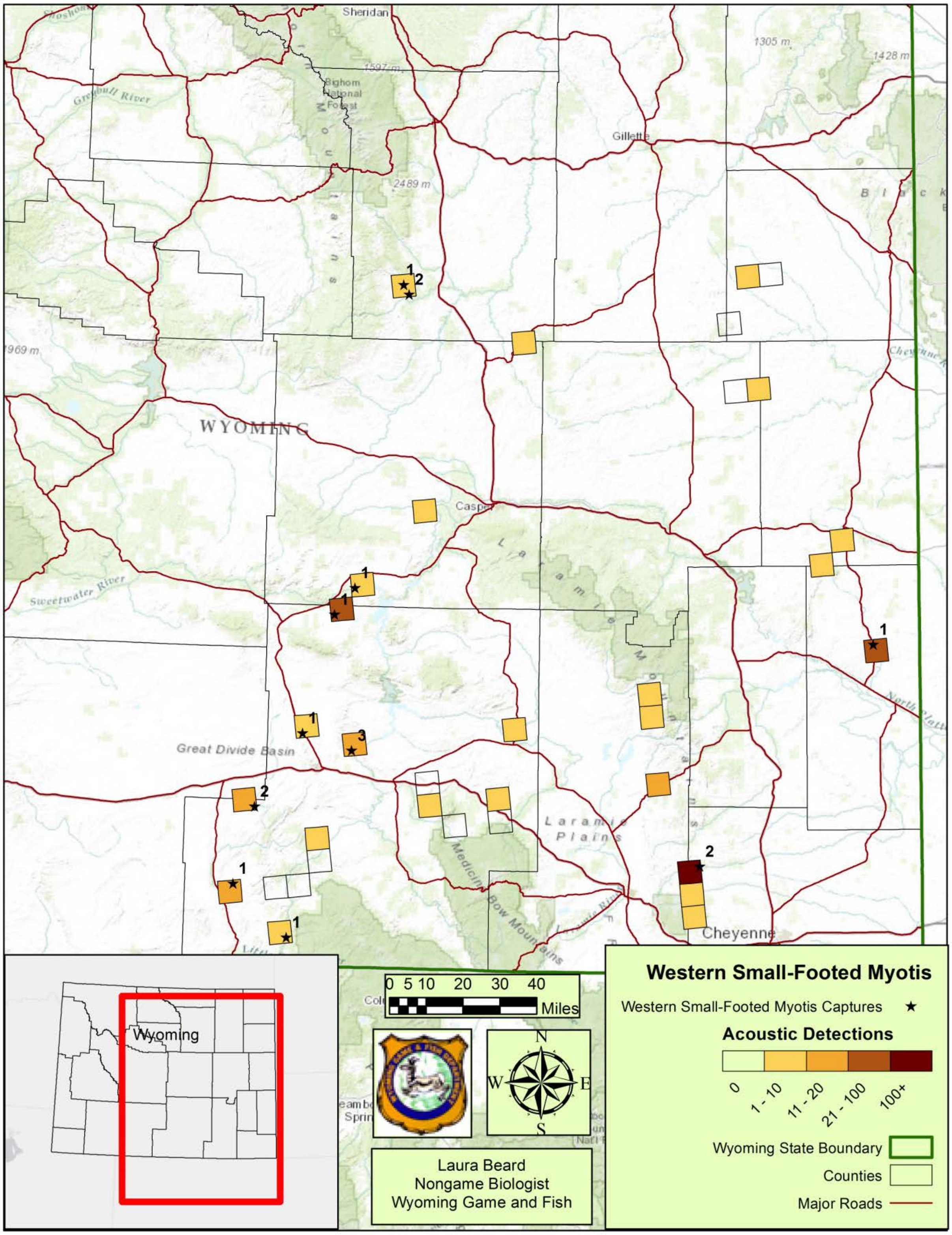


Figure 10. Locations where western small-footed myotis (*Myotis ciliolabrum*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

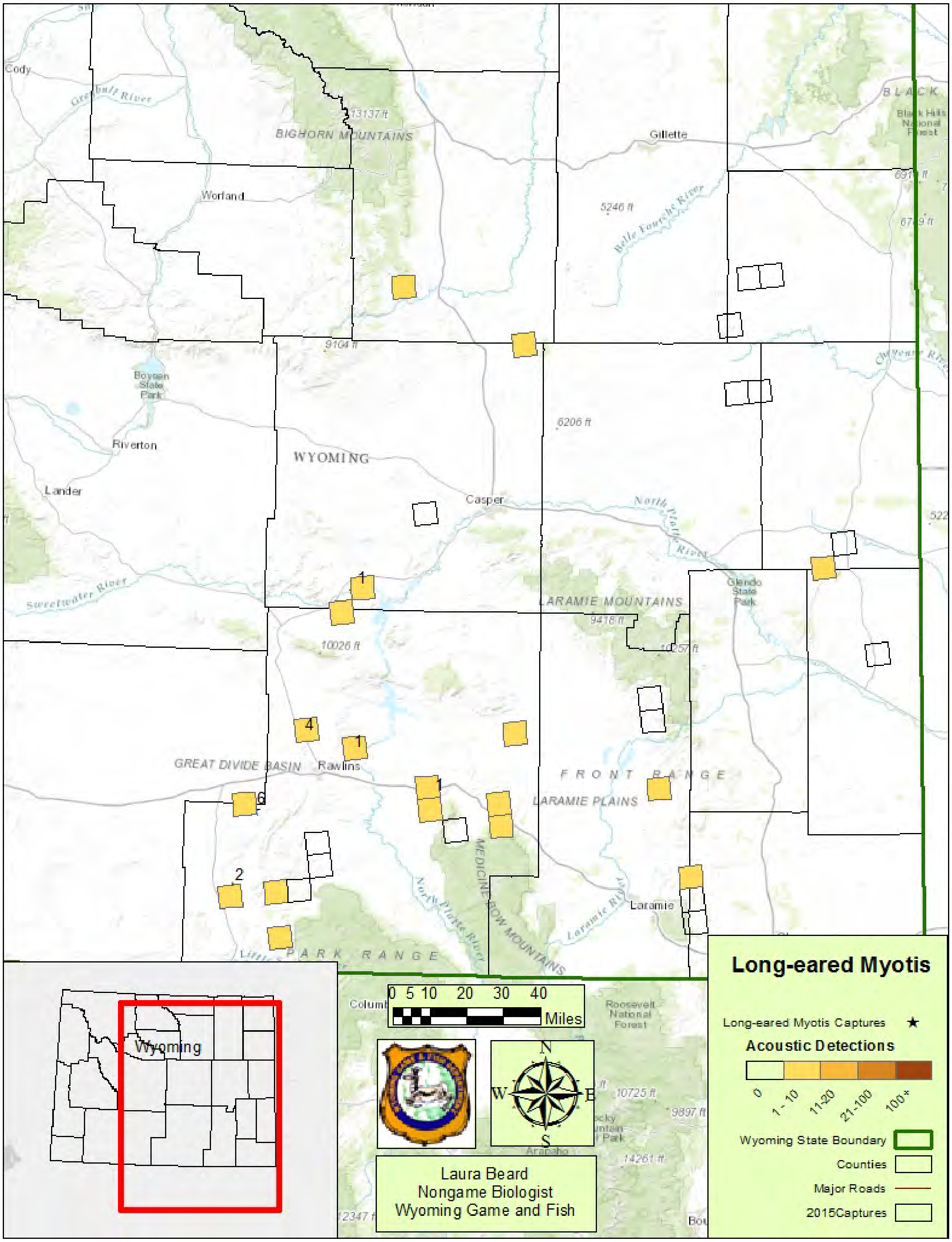


Figure 11. Locations where long-eared myotis (*Myotis evotis*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

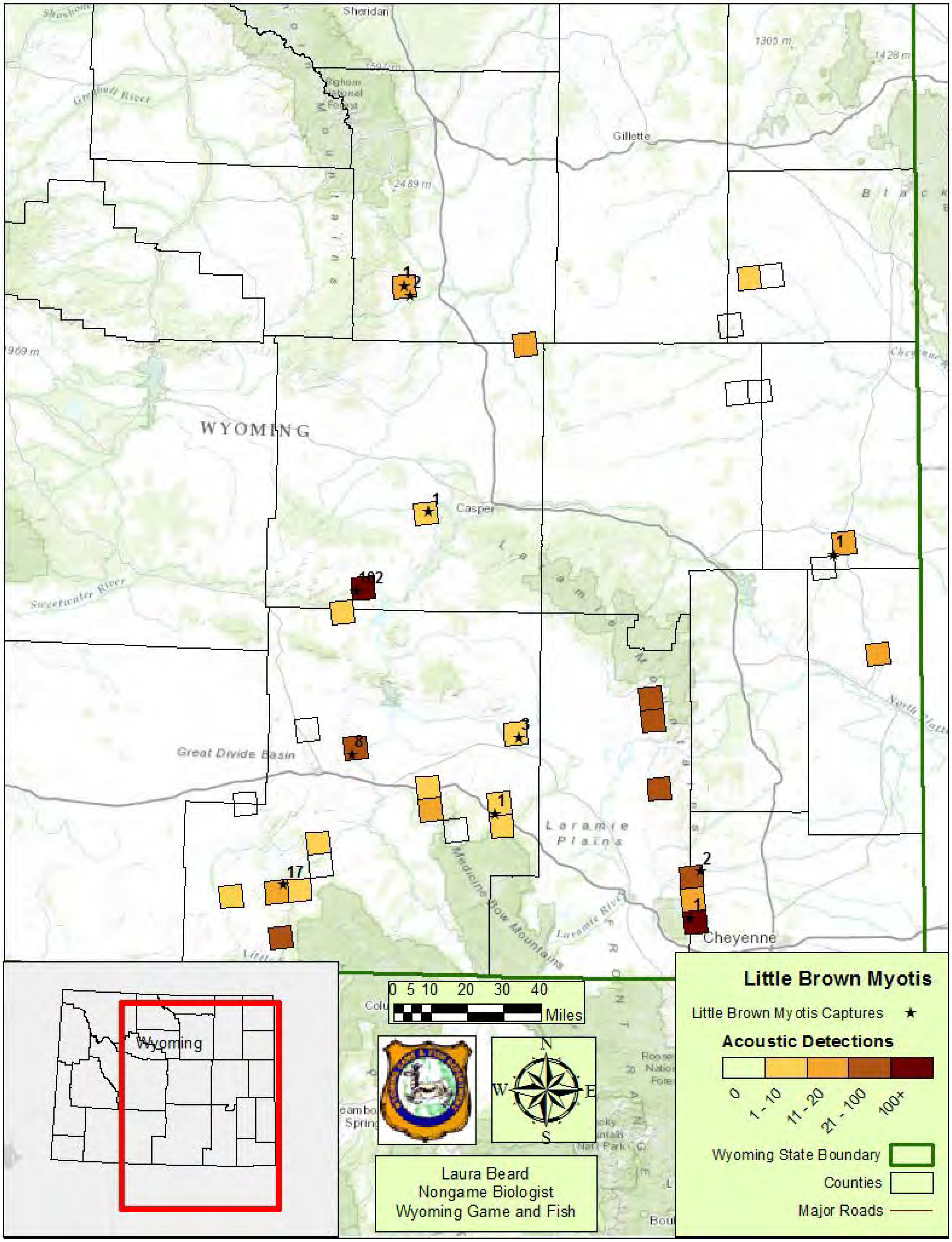


Figure 12. Locations where little brown myotis (*Myotis lucifugus*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

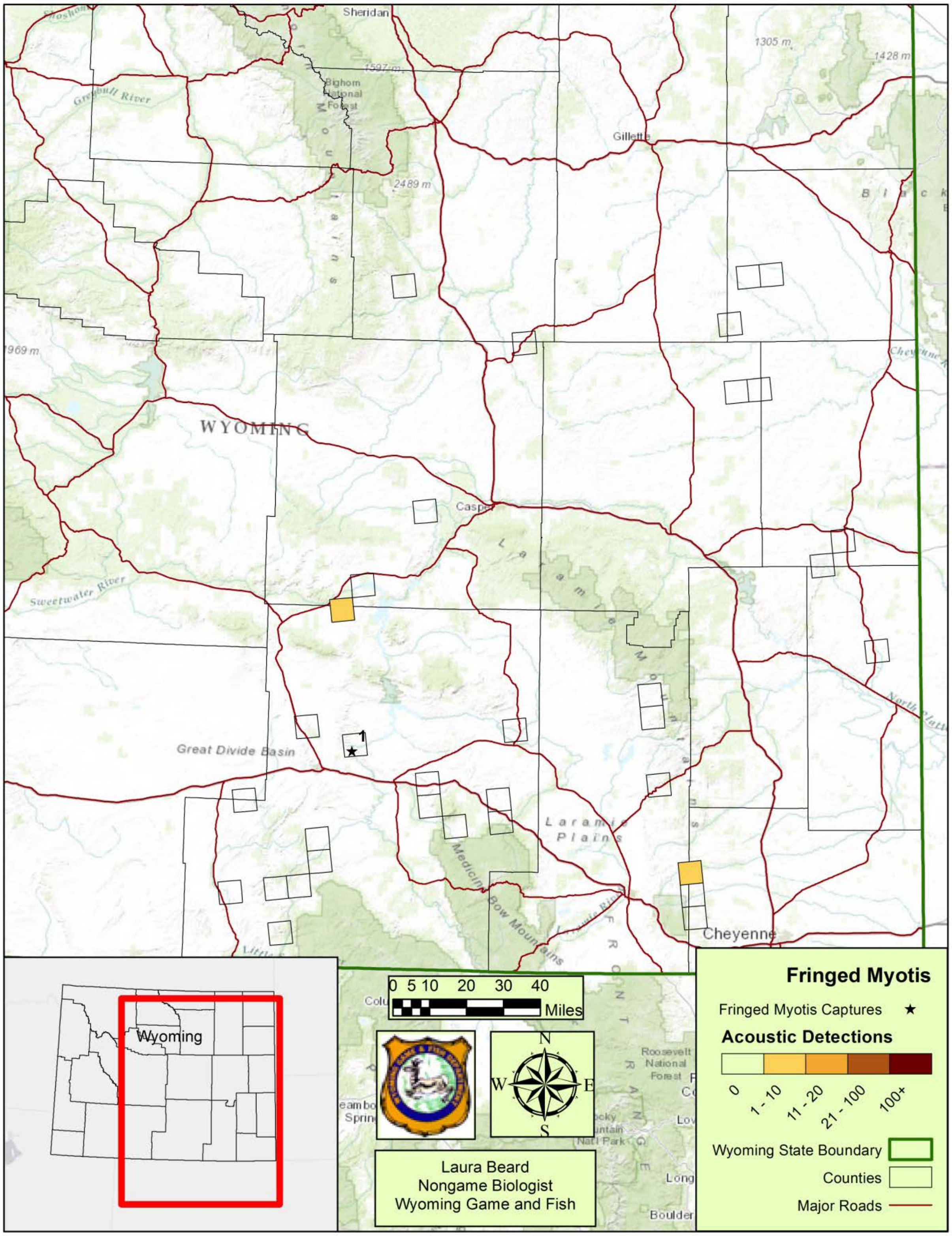


Figure 13. Locations where fringed myotis (*Myotis thysanodes*) were captured and detected in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

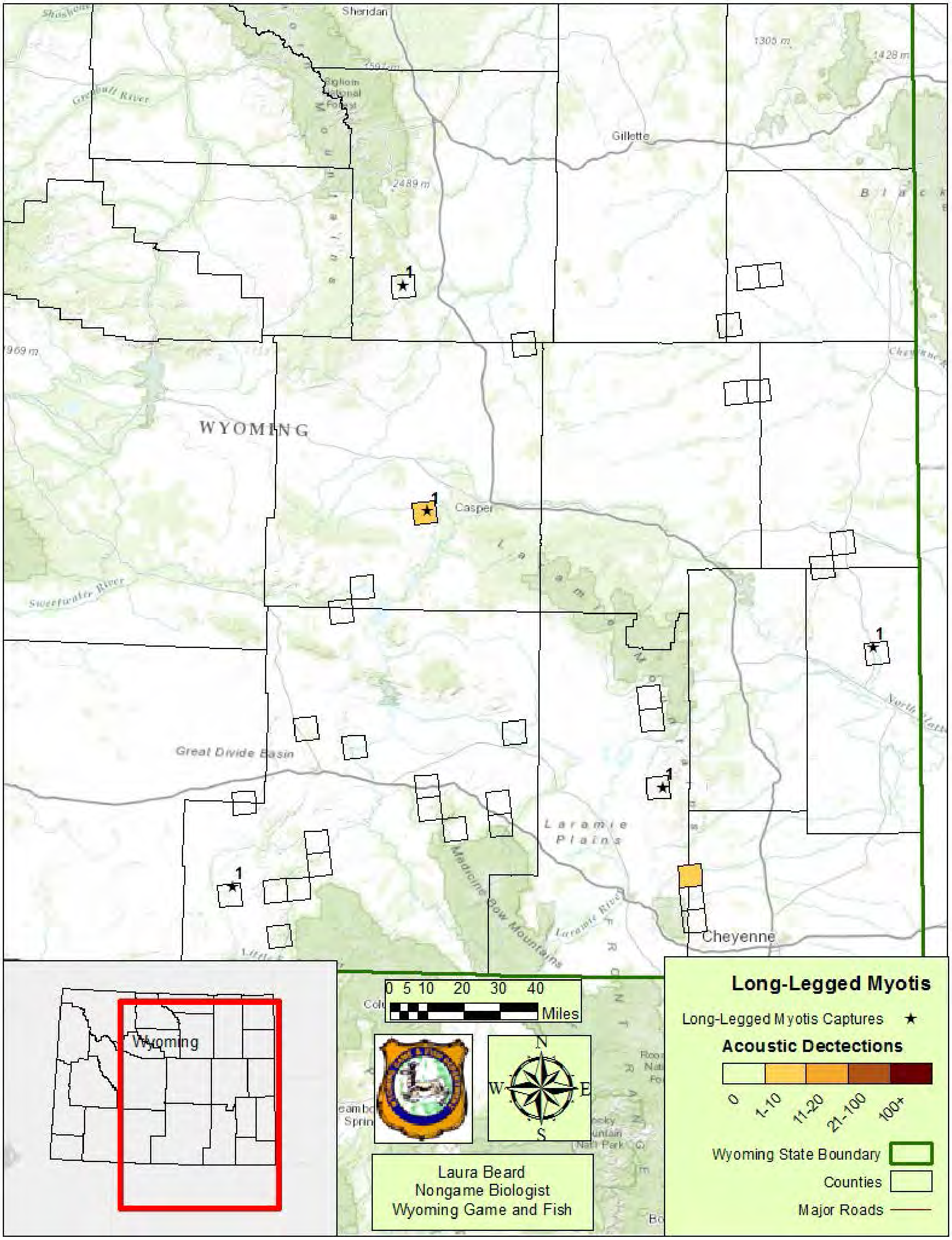


Figure 14. Locations where long-legged myotis (*Myotis volans*) were captured in eastern Wyoming, May-August 2015. Stars within each grid cell represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid cell corresponds to the number of classified call files for this species.

USING GIS MODELING TO EVALUATE RISK OF BAT ROOSTS TO WHITE-NOSE SYNDROME

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2014 – 30 June 2016

PERIOD COVERED: 1 October 2015 – 29 February 2016

PREPARED BY: Brian M. Zinke, Nongame Biologist

SUMMARY

White-nose syndrome (WNS) is a fungal disease that affects hibernating bats in North America (Flory et al. 2012). The fungus, *Pseudogymnoascus destructans*, is of European origin and was first documented in New York in the winter of 2006-2007 (Flory et al. 2012, USFWS 2016). In Europe, the disease has been benign, but it has been exceptionally detrimental in North America, killing an estimated 5.5 million bats in the northeastern US and Canada (USFWS 2016). Infected bats display unusual behavior, such as flying outside during the day and clustering near cave entrances (USFWS 2016). WNS has been confirmed in 27 states in the US, with evidence of the fungus in 3 others (USFWS 2016). In the winter of 2014-2015, the fungus was detected in eastern Nebraska, becoming the first state bordering Wyoming to have the fungus (USFWS 2016). Wyoming currently does not have WNS, but 4 bat species that occur in the state are known to have contracted it in other states (USFWS 2016). Big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*M. septentrionalis*), and American perimyotis (tri-colored bat; *Perimyotis subflavus*) occur in Wyoming and are known to be susceptible to WNS. Eastern red bat (*Lasiurus borealis*) and 2 subspecies of Townsend's big-eared bat (*Corynorhinus townsendii*) have had the fungus detected on them but were not confirmed for the disease. These 2 species also occur in Wyoming.

In an effort to prepare for the potential arrival of WNS in Wyoming, the Wyoming Game and Fish Department (Department) created a strategic plan to address the threat of WNS (Abel and Grenier 2012). One of the features of that plan is to create a model to assess the risk of bat roosts to WNS in Wyoming. This report covers the initial stages of that process.

We organized and recorded historic roost data in digital form in a Microsoft Access database. The data we recorded consisted of physical roost descriptions (e.g., GPS location,

portal dimensions, interior conditions) and survey records (e.g., type of survey, season, bat observations). We conducted hibernacula surveys at new, previously unsurveyed roosts and older, known roosts (refer to Beard [2016] for specifics). For known roosts, we made efforts to fill in any missing information from previous visits. To improve our knowledge of existing mines within the state, we collaborated with the Wyoming Department of Environmental Quality's Abandoned Mine Lands Division (AML).

To-date, we have recorded 602 known or potential roost sites (Table 1). Of those, 414 (68.8%) have been surveyed at least once by Department biologists. In all, we recorded 881 bat roost surveys that have been conducted since 1992 (Table 2). From October 2015 to March 2016, we visited 24 sites. Of those, we were able to survey 11 mines, 6 caves, 1 artificial roost, and 1 man-made bunker. Three of the sites had never been surveyed by the Department before, and we observed hibernating bats for the first time at 5 of the sites (Beard 2016).

The initial data-gathering stage of this project provided several useful insights. First, the Department's historic allocation of resources to bat research has provided a solid foundation from which to begin this risk assessment. With over 880 surveys and 87 known hibernacula, we can begin to look at more refined research questions and trends based on the data accumulated over the last 24 years. Second, despite such an extensive collection of data, there are still gaps that need to be filled. For instance, GPS technology in the early 1990s was substantially limited or completely lacking. As a result, many of the sites have inaccurate or no GPS locations. Accurate location data are crucial for the modeling portion of this project. Other data gaps include the 31.2% of sites that have yet to be surveyed, status of mine reclamations, and standardized temperature and humidity measurements. Third, by combining the first 2 insights, we can better allocate resources and design surveys. By knowing where there are gaps in the data, we can now organize and coordinate efforts to fill in the missing data. Continued partnerships with the AML, Bureau of Land Management, US Forest Service, and private landowners will be critical to locate roosts, gain access to sites, and fill in data gaps.

The final step in the process to develop a statewide assessment of risk is to identify criteria that could be used to evaluate risk of roosts to WNS. However, given the differences in climate, bat behavior, etc. in Wyoming, we will be unable to develop a predictive model at this time. In lieu of a predictive model, we are currently collaborating with the Wyoming Bat Working Group to draw on their cumulative knowledge and expertise to provide hypotheses on relative risk. As more data are collected and our understanding of local risk factors advances, the database and risk values will be updated and used to test predictions related to WNS. The model is expected to be completed by 30 June 2016.

ACKNOWLEDGEMENTS

Funding for this project was provided by the US Fish and Wildlife Service State Wildlife Grants and Wyoming State Legislature General Fund Appropriations, for which the Department is extremely grateful. We thank Department Nongame Biologist L. Beard, who provided critical knowledge and directed the 2015-2016 winter hibernacula surveys. We extend special thanks to

G. Clingerman of the Wyoming Department of Environmental Quality Abandoned Mine Lands program, who helped coordinate mine surveys and provided invaluable data assistance.

LITERATURE CITED

Abel, B., and M. Grenier. 2012. A strategic plan for white-nose syndrome in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Beard, L. 2016. Surveillance of hibernating bats and environmental conditions at caves and abandoned mines in Wyoming. Pages 97-113 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Flory, A. R., S. Kumar, T. J. Stohlgren, and P. M. Cryan. 2012. Environmental conditions associated with bat white-nose syndrome mortality in the north-eastern United States. Journal of Applied Ecology 49:680-689.

United States Fish and Wildlife Service [USFWS]. 2016. White-nose syndrome: the devastating disease of hibernating bats in North America, March 2016. https://www.whitenosesyndrome.org/sites/default/files/resource/white-nose_fact_sheet_3-2016.pdf (accessed 14 March 2016).

Table 1. Number of known or potential bat roosts by type of site, number surveyed during the winter hibernation period (1 November – 15 March), number of verified hibernacula, and the percent (%) of surveyed sites that were hibernacula in Wyoming as of 1 March 2016.

Type of site	Count	Surveyed in winter	Verified hibernacula	% hibernacula of surveyed sites
Mine	244	109	61	56.0
Cave	241	36	25	69.4
Pit	67	0	0	
Building	37	0	0	
Rock shelter	4	1	0	0.0
Tunnel	3	3	0	0.0
Bridge	3	0	0	
Artificial roost	1	1	0	0.0
Bunker	1	1	1	100.0
Cliff	1	0	0	
Total	602	151	87	57.6

Table 2. Number and type of bat roost surveys conducted by the Wyoming Game and Fish Department in Wyoming between 1 January 1992 and 29 February 2016. For interior searches, total number is shown with the winter hibernation subset (1 November – 15 March) in parentheses.

Year	Interior search (winter)	Mist netting	External survey	Acoustic	Unknown	Total
1992	0 (0)	0	0	0	4	4
1993	1 (0)	1	0	0	1	3
1994	98 (22)	58	0	0	8	164
1995	137 (55)	48	1	0	4	190
1996	138 (41)	15	0	0	2	155
1997	19 (9)	7	2	0	0	28
1998	22 (8)	2	0	0	0	24
1999	17 (11)	0	2	0	0	19
2000	3 (3)	0	0	0	1	4
2001	3 (1)	4	0	1	0	8
2002	21 (9)	13	28	1	1	64
2003	19 (6)	1	4	0	0	24
2004	11 (3)	3	1	0	3	18
2005	0 (0)	0	0	0	0	0
2006	0 (0)	0	0	0	1	1
2007	6 (6)	1	7	0	2	16
2008	36 (28)	1	19	0	4	60
2009	16 (15)	3	3	0	0	22
2010	10 (4)	2	2	0	0	14
2011	3 (1)	2	0	0	0	5
2012	11 (4)	2	0	0	1	14
2013	3 (0)	5	0	2	0	10
2014	8 (1)	1	0	0	0	9
2015	12 (8)	0	0	0	0	12
2016	11 (11)	0	2	0	0	13
Total	605 (246)	169	71	4	32	881

DISTRIBUTION OF FEMALE WOLVERINES (*GULO GULO*) IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Wolverine

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2014 – 30 June 2016

PERIOD COVERED: 1 February 2015 – 30 June 2015

PREPARED BY: Nichole Bjornlie, Nongame Mammal Biologist

SUMMARY

Wolverines (*Gulo gulo*) have a circumpolar distribution that used to extend as far south as Arizona and New Mexico in the US (Pasitschniak-Arts and Larivière 1995). Historically, overharvesting and habitat loss nearly eliminated the wolverine from the continental US. Although they have subsequently recolonized portions of their former range, wolverines still exhibit a much-reduced distribution (Pasitschniak-Arts and Larivière 1995) and remain vulnerable from habitat loss and climate change, which led to a petition to list the species as Threatened under the Endangered Species Act (USFWS 2013). Although this listing was ultimately withdrawn (USFWS 2014), a lack of information on the status and distribution of wolverines in Wyoming led the Wyoming Game and Fish Department to contract with The Wolverine Initiative in 2015 to conduct a pilot project to address these questions. The following is a summary of the report by Inman et al. (2015); for the full report, please see Appendix A.

In order to detect wolverines, Inman et al. (2015) overlaid predicted habitat in Wyoming with a grid composed of 15x15 km grid cells. They randomly selected 18 cells and deployed infrared cameras coupled with bait and lure scents to detect wolverines from February through June 2015. Specific camera locations within a cell were determined based upon accessibility, proximity to alpine tree line, and location of natural movement corridors. Over 1,618 survey days, Inman et al. (2015) collected 70,036 photos, including 8,213 photos of wolverines at 5 cells. Based upon unique ventral pelage, ≥3 unique wolverines were detected at sites in the Gros Venter, Wind River, and southern Absaroka Mountain Ranges. From these detections, Inman et al. (2015) estimated an occupancy of 62.9% (95% CI: 36.2 to 83.7) throughout the study area, and a probability of detection of 32.1% (95% CI: 12.8 to 57.5). In addition to remote cameras, they also affixed barbed wire to bait trees in order to collect hair for genetic analyses. In all, 65 samples were collected, which resulted in genetic confirmation of wolverines at 2 cells where they had been documented on cameras. Other samples were confirmed to be red fox (*Vulpes vulpes*), coyote (*Canis latrans*), mule deer (*Odocoileus hemionus*), Pacific marten (*Martes*

caurina), or black bear (*Ursus americanus*). This survey highlights the effectiveness of remote cameras coupled with bait stations to detect wolverines in Wyoming, and provides a framework that will be incorporated into a multi-state monitoring effort that will begin in the winter of 2015-2016.

LITERATURE CITED

Inman, R., M. Riley, Z. Walker, B. Lanka, and G. White. 2015. Distribution of female wolverines in Wyoming, progress report – August 2015. The Wolverine Initiative, Ennis, Montana, USA.

Pasitschniak-Arts, M., and S. Larivière. 1995. *Gulo gulo*. Mammalian Species 499:1-10.

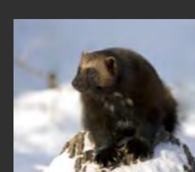
United States Fish and Wildlife Service [USFWS]. 2013. Endangered and threatened wildlife and plants; threatened status for the distinct population segment of the North American wolverine occurring in the contiguous United States. Federal Register 78:7864-7890.

United States Fish and Wildlife Service [USFWS]. 2014. Endangered and threatened wildlife and plants; threatened status for the distinct population segment of the North American wolverine occurring in the contiguous United States; establishment of a nonessential experimental population of the North American wolverine in Colorado, Wyoming, and New Mexico. Federal Register 79:47522-47545.

Distribution of Female Wolverines in Wyoming

Progress Report – August 2015

Robert Inman, Meghan Riley, Zack Walker, Bob Lanka, and Gary White
The Wolverine Initiative
Wyoming Game and Fish



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Background

Wolverines (*Gulo gulo*) historically existed in the Rocky Mountains of the western U.S., but the population was eliminated, or very nearly so, by about 1920 (Aubrey et al. 2007). By the 1930's wolverines from Canada were reoccupying their historical range to the south (Newby and Wright 1955, Newby and McDougal 1964, Aubrey et al. 2007). At present, breeding populations of wolverines appear to have reoccupied their historical range within Montana and Idaho along with at least portions of their range within Wyoming and Washington (Hornocker and Hash 1981, Copeland 1996, Aubry et al. 2007, Squires et al. 2007, Anderson and Aune 2008, Copeland and Yates 2008, Murphy et al. 2011, Inman et al. 2012, Aubry et al. 2012, Magoun et al. 2013). In the Rocky Mountains, the line between areas with or without reproductive females has not been defined by systematic sampling, but appears to lie somewhere within Wyoming (Figure 1).

The historical range of wolverines in the western U.S. represents the southernmost area of distribution for the species. At these latitudes, wolverines select high elevation habitats (>2,600 m). In Greater Yellowstone, adult females occupied ~300 km^2 territories; adult male territories were 800 km^2 and typically encompassed 2-3 female territories (Inman et al. 2012). Density was estimated at 3.5 wolverines/1,000 km^2 of area >2,150 m elevation (Inman et al. 2012). These characteristics, along with low reproductive rates, are prevalent throughout the species range (Magoun 1985; Landa et al. 1998; Persson et al. 2006, 2010; Golden et al. 2007). Although most large carnivores in Greater Yellowstone either hibernate or migrate along with ungulate herds during winter, the wolverine remains active at higher elevations, using its large feet to patrol a vast, frozen territory that is covered in snow. Successful exploitation of these relatively unproductive environments requires large home ranges that are regularly traversed, territories that provide exclusive intra-specific access to resources, and low densities.

It is likely that wolverines in the western U.S. have always existed as an alpine metapopulation where roughly 600 individuals can exist on islands of high-elevation habitat distributed across nine western states (Inman et al. 2013). Wolverines are a species of greatest conservation need in seven western states, including Wyoming (WGFD 2010). The USFS and BLM consider wolverines to be a sensitive species, and the USFWS recently proposed to list the species due to the threat of climate change (USFWS 2013a). Conservation priorities for wolverines have been identified by a collaboration of state, federal, and private biologists as 1) conserving open lands to maintain successful dispersal, 2) restoring wolverines to areas of historical range that have not been reoccupied, and 3) establishing a multi-state population monitoring program to better inform conservation needs and measure progress (Inman et al. 2013). Similar needs were presented in the USFWS's draft recovery outline (USFWS 2013b) and the Idaho Department of Fish and Game's Wolverine Conservation Strategy (IDFG 2014). This project is focused on the initial stages of monitoring.

While our understanding of wolverine ecology and conservation needs has improved in recent years, we still lack basic information on population distribution, numbers, and trend

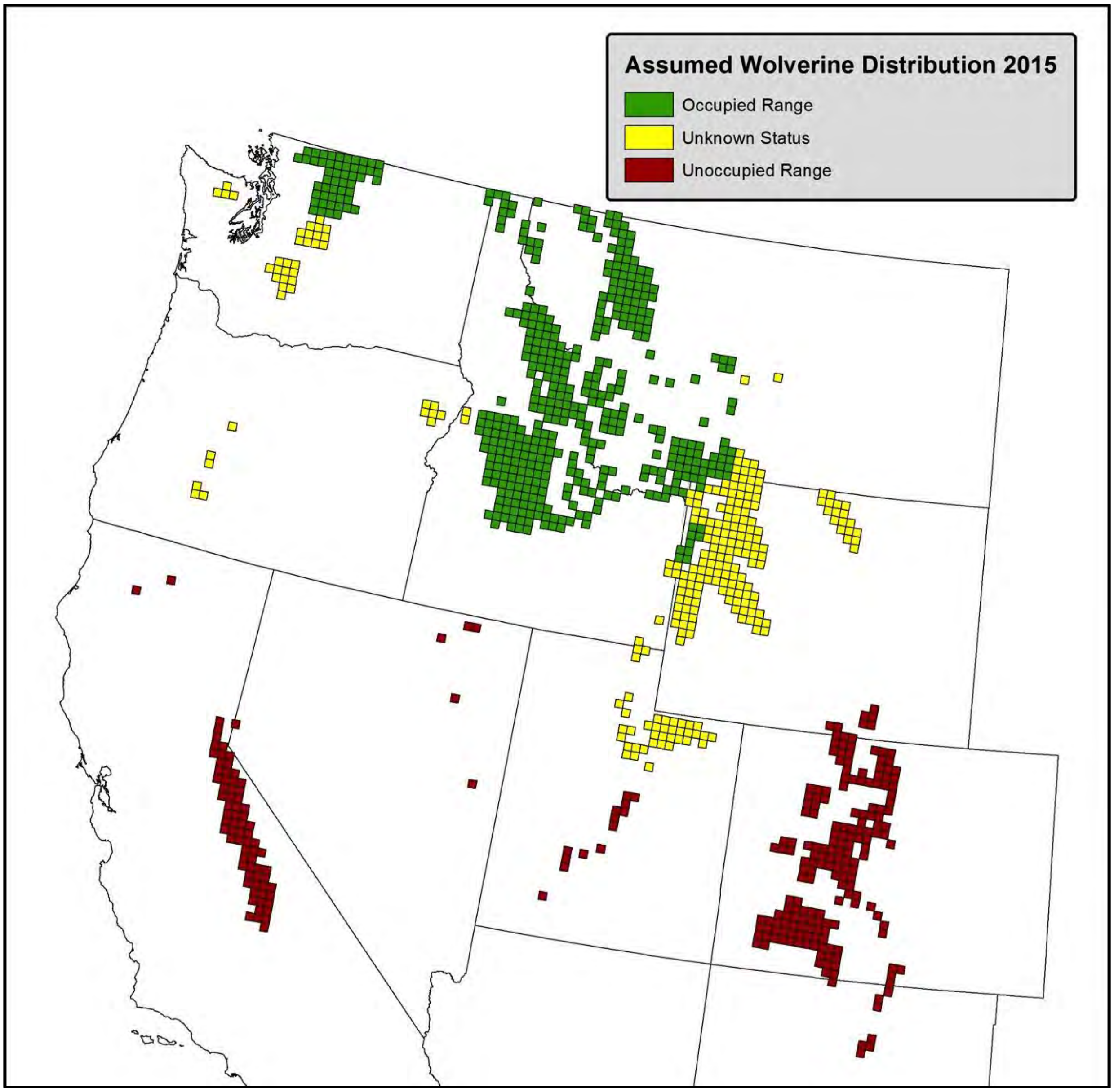


Figure 1. General areas of suitable habitat with and without evidence suggesting female wolverines have reoccupied their historical range within the contiguous U.S. after near complete extirpation ~1925. Green areas have some evidence of recent occupation by a breeding population based on documentation of reproduction and/or number and consistency of verified records (Hornocker and Hash 1981, Copeland 1996, Aubry et al. 2007, Squires et al. 2007, Anderson and Aune 2008, Copeland and Yates 2008, Murphy et al. 2011, Inman et al. 2012, Aubry et al. 2012, Magoun et al. 2013). Yellow areas are of unknown status as they are generally adjacent to re-occupied areas but have not yielded consistent verified records or evidence of reproduction. Red areas are very likely unoccupied by females as they have had no evidence of a breeding population or even individuals since the early 1900's (with the exception of a single male in each of California and Colorado in 2008 and 2009 respectively, both the first confirmed records of the species in those states in nearly 100 years).

throughout the species range in the contiguous U.S. Our current understanding of the distribution of reproductive female wolverines is based on trapping records and carcass examinations in Montana and a few telemetry studies (Figure 1). This information, along with a lack wolverine detections in Colorado and California for nearly 100 years (Aubry et al. 2007), suggests that the "front line" of wolverine reoccupation occurs somewhere in Wyoming. Because of the contiguous nature of much of the suitable wolverine habitat in Wyoming and its proximity to areas where reproductive females have occurred for decades, much of Wyoming may in fact be occupied by reproductive females. Sporadic reports of wolverine tracks and sightings occur in areas beyond those known to be occupied by reproductive females; however, the ability of wolverines to disperse long distances (Inman et al. 2012) and the lack of a systematic survey leaves the presence of reproductive females questionable in much of the state.

The currently available information suggests that only a portion of Wyoming's wolverine habitat can be confidently assumed to be occupied by reproductive females. Given that Wyoming appears to have the capacity to hold approximately 20% of the wolverine population of the western U.S. (Inman et al. 2013), this gap in our knowledge is significant for Wyoming and in the context of the wolverine population of the western U.S.

The Wyoming Game and Fish Department classifies the wolverine as a Species of Greatest Conservation Need with a Native Species Status of 3 (NSS3) because its populations are restricted in numbers, its habitat is vulnerable, and it may be sensitive to human disturbance. Wolverine conservation problems cited in Wyoming's State Wildlife Action Plan (SWAP) include:

1. Existing disagreement about status and distribution of historic populations in Wyoming;
2. Population densities and trends are not well known;
3. Geographical isolation of existing wolverine populations may leave them vulnerable to demographic and genetic stochasticity.

Conservation actions suggested in Wyoming's SWAP include:

1. Conduct inventories for species in all suitable habitats in the state.
2. Improve survey methodology (e.g., capture, detection, etc.).
3. Monitor population densities and trend.
4. Evaluate the potential to translocate species to bolster populations in some areas of the state.
5. Designate important habitats, habitat corridors, and identify where habitat conservation and management efforts should focus to protect, enhance, or improve suitable habitat.
6. Continue active participation with interagency conservation efforts.

This work addresses multiple conservation actions listed above from Wyoming's SWAP. This work will provide a baseline to monitor trends in wolverine occupancy within Wyoming, which will aid assessments of the degree to which the species has recovered from historical extirpation. This information will be relevant to wolverine management in Wyoming and ongoing federal assessments that affect Wyoming. This work will also aid in the initiation of a multi-state monitoring program by 1) documenting areas where female wolverines could be targeted for future monitoring efforts, 2) refining non-invasive sampling techniques, and 3) providing genetic samples from an area of distribution that has not been included in previous analyses (Cegelski et al. 2006, Schwartz et al. 2009). Data from this project will provide updated information to address deficiencies and conservation actions identified in habitat and individual SGCN accounts in the State Wildlife Action Plan (SWAP), including data on geographical distribution, population attributes, and occupancy trends of wolverines as well as increase observational records and revise predictive distribution and range models for wolverines in Wyoming. These data will be used to revise the SWAP as well as the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Atlas) and increase records of occurrence in the Wildlife Observation System (WOS).

Objectives

We used non-invasive sampling techniques (Magoun et al. 2011, Fisher et al. 2013) in suitable habitat (Inman et al. 2013) to detect wolverines in order to meet the following objectives:

1. Identify the extent of wolverine range, especially females, in Wyoming to improve understanding of current distribution.
2. Document female wolverine locations to facilitate future radio-collaring efforts aimed at identifying female territories and monitoring population status via female survival, reproduction, and territorial occupancy.
3. Field test and refine non-invasive sampling techniques to assess utility for future wolverine monitoring efforts.
4. Collect genetic samples to assess connectivity of wolverine populations and verify female wolverine detections.
5. Provide additional observation records for wolverine to the Department's WOS.

Study Area

The Absaroka, Gros Ventre, Wind River, Salt River, and Wyoming mountain ranges occur in northwestern Wyoming (Figure 2). These mountain ranges form a node, running together in the vicinity of Hoback Junction, Union Pass, and Togwotee Pass. Elevations in these mountains range from approximately 1,890–4,206 m above sea level. Predominant habitat types include montane forest, subalpine forest, mountain grasslands, and alpine tundra (See photos in Appendix 1). Permanent ice and snow fields occur in the two largest mountain ranges: the Absaroka and Wind River Range. Lands in the study area primarily occur in the Shoshone National Forest, Bridger-Teton National Forest, and Wind River Reservation.

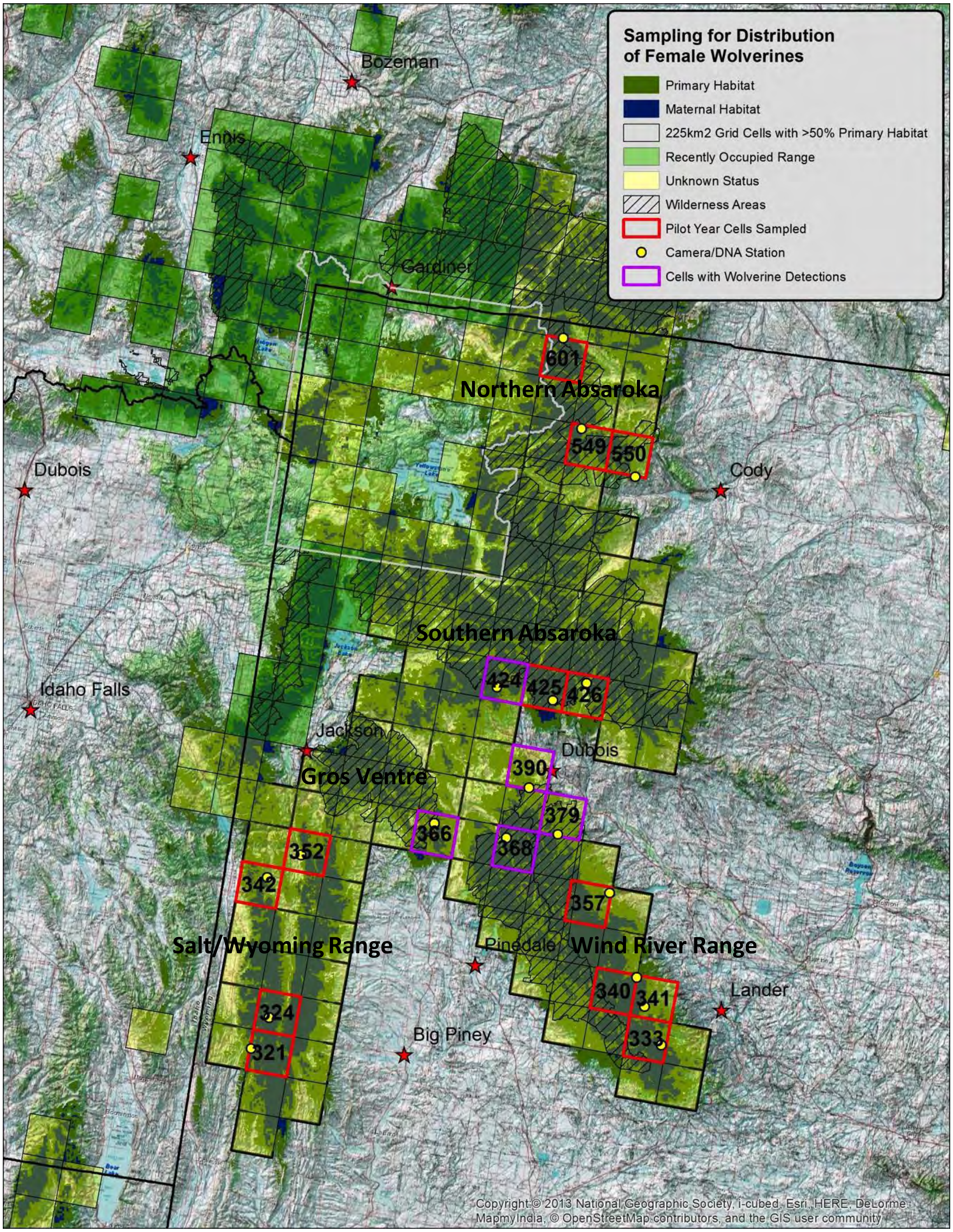


Figure 2. Zoom-in to northwest Wyoming with layers representing primary and maternal habitat, known recent occupation vs. unknown status, and designated wilderness. We sampled red cells during the winter and spring of 2014-2015 but did not detect a wolverine (*n*=13 cells). We did detect a minimum of 3 individual wolverines in the purple cells (*n*=5 cells).

Methods

We sampled for wolverine presence using a 15 x 15 km grid (225 km^2) of cells that were >50% primary wolverine habitat (Inman et al. 2013; Figure 2). The 225 km^2 grid cells were smaller than the 300 km^2 average female wolverine home range size reported for Greater Yellowstone (Inman et al. 2012). Cells considered for sampling were limited to the area of "unknown status" within Wyoming and outside of Yellowstone National Park (Figure 2). We used GRTS sampling (Generalized Random Tessellation Stratified; Kincaid and Olsen 2011) to select cells, and we established one camera/DNA station per grid cell (Figure 2).

We used Reconyx infrared cameras, models RC60, PC55, PC900C, PC800SC, PC850WF. We determined general and specific station placement within the selected grid cells while on the ground and based on accessibility, proximity to alpine tree-line, and location of natural movement corridors (e.g. mountain passes and saddles). We baited stations with road-killed deer or trapper-donated beaver carcasses wired to a tree. We also placed scent lures and deer rumen at bait stations. At sites outside of designated wilderness (n=8), we suspended baits above a run-pole and frame in order to identify sex and reproductive status of wolverines via camera and DNA (Magoun et al. 2011, Figure S1). At sites within designated wilderness (n=10), we made photos and collected hair samples from barbed wire wrapped loosely around baited trees (Fisher et al. 2013, Figure S2). We attached infrared cameras to trees oriented towards the bait tree or run-pole and frame, generally pointed north to reduce backlighting.

Biologists deployed stations and then revisited to collect hair samples, check camera batteries and memory cards, and replenish bait and scent. We collected hair samples using latex gloves and stored them in paper envelopes in Ziploc bags with desiccant. We collected scat samples opportunistically and stored as described for hair samples. Sampling occurred during Feb–June 2015 and stations were checked approximately once a month. Cameras will remain operational during summer 2015 with scent lure as the only attractant. Hair samples will be sent to the National Genomics Laboratory for Wildlife and Fish Conservation in Missoula, MT for analysis. Samples will be identified to species and wolverine hair samples may be further classified to sex and individual using follicular DNA (Magoun et al. 2011). Following initial analysis, wolverine samples will be stored for more extensive DNA analyses to occur at a later date.

We estimated probability of occupancy for sampled sites with the single-season occupancy model of MacKenzie et al. (2006), with detections categorized by months resulting in 5 occasions. We considered models with constant and time-varying detection rates (p), and with probability of occupancy (ψ) and p modeled as a logistic function of average elevation of the sampled cell.

Results

Station Activity

During this pilot season, we deployed 18 infrared cameras along with hair snares at bait stations. These 18 stations were distributed within the Northern Absaroka (*n*=3), Southern Absaroka (*n*=3), Wind (*n*=7), Gros Ventre (*n*=1), and Salt/Wyoming (*n*=4) mountain ranges (Figure 2). We established stations between 9 Feb–20 Mar. The quantity of bait brought to each site varied depending on availability of road kill and extent of snowmobile accessibility. Because funds were not available to spend as early as anticipated, we initiated deployment of stations during February rather than earlier in the winter. We visited stations an average of three times (range = 2–5) from 9 Feb–28 Jun.

Data Collected

We ran camera traps for 1,913 trap nights. Most camera traps remained operational for the duration of deployment, although there were five instances of camera batteries dying before a check and three instances of bears knocking cameras out of position. Total days sampled (i.e., camera operational) was 1,618. We sampled stations an average of 90 days/station (range = 11–135 days; Table 1). Our cameras collected 70,036 photos, including 8,213 of wolverines.

We collected 65 genetic samples at the stations, including 31 samples at stations where wolverines were documented on camera. We collected 48 DNA samples from barbed wire, 15 from alligator clips, and 2 from scats located on the ground at stations (Table 1). DNA samples (*n*=65) were delivered to the lab in Missoula on July 31, 2015 and analysis should be completed by September.

Wolverine Detections

We detected wolverine presence at five stations in Wyoming, including one station in the Southern Absaroka Range, one station in the Gros Ventre Range, and three stations in the Wind River Range (Table 1, Figure 2, photos in Appendix 2). We had one additional "possible" wolverine detection in the Salt/Wyoming Range, but the night photos were too dark to determine the species with confidence. Elevation at stations averaged 2,740 m. (range = 2,137–3,184 m., Table 1). Elevation at sites with wolverine detections averaged 2,925 m. The lowest elevation of a detection was 2,528 m.

We documented 53 wolverine visits, having defined a visit as a period during which intervals between wolverine photographs did not exceed one hour. The first wolverine detection occurred in February, but detections were most numerous in April (Table 2). After initial bait station deployment, the number of days until first wolverine detection on camera at various sites ranged from 16–51 days (Table 2). The interval between most recent baiting (at deployment or site check) and first wolverine detection ranged from 5–16 days. These data on latency times should be interpreted with caution given that 1) cameras were nonoperational on nine occasions during the survey period and 2) different volumes of bait were used at different stations.

Detection and Occupancy

From the minimum AIC$_c$ model $\{p(.)\ \psi\}$, $\hat{\psi} = 0.629$ with SE 0.127 and 95% profilelikelihood confidence interval 0.362 – 0.837; and $\hat{p} =$ 0.321 with SE = 0.119 and 95% profile likelihood confidence interval 0.128– 0.575. This estimate of *p* gives a high probability of detecting wolverines at a site if they occurred over the 5-month sampling period: $1-(1-0.321)^5 = 0.856$. Models with elevation modeling ψ or *p* were not ranked higher than the $\{p(.)\ \psi\}$ model, likely because of the small sample size (Table 3). Likewise, we would expect the time-specific model $\{p(t)\ \psi\}$ would rank higher with a larger sample size.

Number of Individuals

Based on review of the markings of wolverines photographed, we determined that at least three individuals visited our bait stations (Figure S3). Of these, only one wolverine was photographed with a complete view of its ventral markings, allowing for positive identification (W0001). We photographed another wolverine with white forelimbs, but have no photos of this individual's chest markings. Both of these individuals were photographed in cell 424 on a Magoun-style run-pole and frame. At the remaining stations that detected wolverines, all of which were "bait-on-tree" stations without a run-pole and frame, photos show only partial views of chest markings. These markings do not match either of the wolverines from cell 424 (Figure S3). Given similarities between these partial views of markings, a single wolverine may have visited all four remaining sites. These sites are located in close proximity to one another, from 12–17 miles apart, in nearly continuous wolverine habitat. DNA samples may improve our understanding of the number of individuals visiting stations.

Female Wolverine Detections

Though not a direct result of our sampling, this winter's efforts resulted in the understanding that an adult female wolverine has likely occupied the south-central Absaroka's for nearly eight years. During 2006, female F133 was captured as a juvenile in the Gallatin Range of Montana to the northwest of Yellowstone National Park (Inman et al. 2012). She dispersed from Montana to Wyoming during 2007 and was radio-located near the southeastern corner of Yellowstone National Park through 2009 (Inman et al. 2012, Murphy et al. 2011).

While visiting with partners at Wyoming Game and Fish, and examining photos made on a fisher survey during the winter of 2013-14, it became apparent that a wolverine photographed in Fishhawk Creek was almost certainly F133 (Figure S4).

Photographs from this sampling session did not provide sufficient detail to identify sex or reproductive status of wolverines. Despite photographing W0001 standing up on a run-pole, we were unable to positively assign sex due to poor image quality. Genetic samples have not yet been analyzed for sex identification. We collected 48 genetic samples from barbed wire and 15 genetic samples from alligator clips. We also collected two likely wolverine scats for DNA analysis. Analysis of DNA samples collected may reveal whether a female wolverine visited one of our bait stations, but photos of superior quality would be necessary to determine sex and reproductive status of any wolverines photographed next year.

Non-target Species

We detected 25 additional species on camera at the stations, including 17 mammals (Table 4) and 8 birds (Table 5). Of the mammal species, marten (*Martes americana*) were photographed at the most stations. Clark's nutcrackers (*Nucifraga columbiana*) were photographed at the most stations of the bird species. We detected marten at 15 of the 18 stations (83%) and grizzly bears (*Ursus arctos*) at 4 of the 18 stations (22%). Select non-target species photos are in Appendix 3.

Discussion

Extent of Wolverine Range in Wyoming

Aubrey et al. (2007) conducted an exhaustive search for verifiable wolverine occurrence records in the contiguous U.S. They found one recent (1961-1994) and 12 current (1995-2005) records in Wyoming. Of the 12 current records, 9 occurred in the Teton Range and were made via capture during a radio-telemetry study (Inman et al. 2012). Of the four remaining records in Wyoming over that 44-year period, one was a roadkill of a young female near Kemmerer in 2004 and one was an incidental capture of a male by a fur-trapper near Cheyenne in 1996. Both individuals could have been dispersers travelling long distances (Vangen et al. 2001, Inman et al. 2012). The other two records appear to have come from near the northern border of Yellowstone National Park and near Jackson Hole (Aubrey et al. 2007). Additional verified records in Wyoming are limited to the documentation of a single dispersing-aged female. F421 was born in the Teton Range during 2004 and dispersed to the Salt Range during 2005 (Inman et al. 2012).

She resided in the Salts for approximately one year, after which she dispersed to the Wind River Range during 2006. She remained in the Winds at least until August of 2007 when contact was lost. It is unknown whether this female went on to maintain a territory or reproduce in the area.

This winter's work added considerably to the documentation of wolverine presence in Wyoming. We detected a minimum of three individual wolverines in Wyoming with at least one in the Gros Ventre and Wind River mountain ranges and at least two in the Southern Absaroka mountain range. The detection in the Gros Ventre was the first verified occurrence of a wolverine in that mountain range. This winter's work also established at least some form of continued presence in the central Absarokas, southern Absarokas, and Wind River Ranges. DNA analysis may reveal additional individuals or females. This pilot season also provided valuable information for planning future efforts.

Non-Invasive Monitoring

State Variable of Interest

The value of sampling for occupancy lies in the question answered, the precision of the answer, and ultimately this answer's ability to generate and guide management action. Information on wolverine occupancy could be particularly "noisy" due to the species' low densities combined with the ability of young dispersing animals of both sexes to cover long distance in a few days, e.g., 412 km in 19 days (Vangen et al. 2001, Inman et al. 2004, 2012). Because the biology of the wolverine makes interpretation of occupancy analyses for management purposes even more difficult than usual, it is important to focus on the state variable of greatest value.

Our objective was to determine if female wolverines were present, especially reproductive females. Though documenting presence of reproductive females is difficult, we focused on this state variable because we believe it lends the greatest confidence to interpretation of current wolverine range and better informs the direction of potential management actions.

Detection of reproduction eliminates the possibility of overestimating the extent of a core reproductive population due to detections of long-distance dispersers. Likewise, resident females may occupy a home range, yet fail to produce litters in cases where source-sink dynamics are in play and environmental conditions do not favor successful reproduction. Documentation of reproduction also provides information on male presence in the area and future presence of some average number of offspring. This information can be incorporated into occupancy analyses via use of multi-state models (MacKenzie et al. 2009). As the example provided in that paper illustrates, determining the occupancy rate of reproducing females would be a significant improvement over estimating overall probability of occupancy of any wolverine. These data can lend confidence to one-time assessments and improve information on trend over time. Furthermore, documentation of female reproduction in Wyoming is of singular importance to determining present extent of wolverine range, which, in turn, has implications for conservation of wolverines in the lower 48 states.

While unable to determine sex or reproductive status of wolverines detected during our first winter of sampling, we believe pursuit of this information to be important and potentially fruitful in certain cases. For the multi-state monitoring program, with an objective of tracking wolverine occupancy over time, participants elected not to use run-poles to determine reproductive status of females as this information has no bearing on the output of occupancy models. However, in areas on the periphery of currently documented wolverine range, determining whether wolverines are reproducing would benefit wildlife managers. Because DNA cannot yield information on reproductive events, biologists should consider using run-poles and frames in cases where verification of a reproductive wolverine population has important management implications. Instructions on improving camera trap performance for determining sex and reproductive status are detailed under "Recommendations".

Sampling Design

Our sampling effort was adjusted in late February after meeting with wolverine range state agencies and beginning to develop a multi-state monitoring effort for the lower 48 states. We had initially planned to sample 250 km^2 cells in clusters of what appeared to be the best wolverine habitat in each major mountain range – an intensive sampling of the "best of the best" habitat in each range. We changed our sampling grid to 225 km^2 to match the grid to Idaho's Multi-species Baseline Initiative sampling. We also selected cells using GRTS sampling in an effort to be able to more rigorously infer the distribution of wolverines within an entire mountain range based on our sampling. This resulted in sampling some areas that met the qualification to be included in the sample (>50% primary habitat), but reduced the overall placement of stations within what we believed to be the highest quality areas, i.e. areas with the most maternal habitat (Inman et al. 2013). Our original sampling scheme of this area where wolverines were not known to exist was based on the premise that "if they are present at all or in low numbers, they will be in the highest quality habitat." The GRTS sampling approach is certainly more suitable for the needs of the multi-state monitoring effort, obtaining an estimate of occupancy in a way that can be examined for change over time. However, wildlife managers should be aware that this approach may be more likely to produce results suggesting wolverines are absent from an area where the species occurs. In cases where managers wish to verify wolverine presence or absence with a greater degree of confidence, stratification into areas of 1) recent known occupation and 2) no recent evidence of occupation, allowing for independent sampling schemes, may be worthwhile.

Logistical Planning

One of the most important costs associated with establishing and maintaining these stations and for planning similar work in other areas is travel time. Work, once at a site, takes about one hour (slightly more for station establishment, slightly less for checking). This year, traveling from a parking area to check a bait station and back took six hours, on average. The shortest site check took 2.5 hours while the longest took 12 hours. These times do not include highway travel to the parking area, thus days may be considerably longer depending on where the survey crew drives from. Accordingly, travel to access points and then to stations takes enough time that only one site per day can be visited typically. This is, of course, dependent on the type of access. Areas outside of designated wilderness where snowmobiles can be used exclusively take less time, but establishment of stations is still limited to about two per day in daylight because of the distance between the 225-km^2 grid cells. Drive time between cells can easily be over an hour. Thus, even for more accessible sites, it can take an hour to drive to the snowmobile parking area, an hour to snowmobile to the station, an hour to check the station (more at initial establishment), an hour to snowmobile out, and an hour or two to drive to the next access point. Where multiple cells can be dealt with from the same snowmobile access point, this time might be reduced to the point where 3-4 stations could be checked in a day under the best circumstances (i.e. good snow, sufficient daylight, stations already established). For sites where hiking or skiing is required, one site per day is appropriate for planning purposes.

When choosing a specific station location within a 225km^2 grid cell, there are obviously many options. However, station placement in a likely travel corridor, near higher quality habitat, or in a location with favorable scent dispersion may be key in detecting a wolverine. Selecting a location on the day a station will be established is not advised. Time constraints will likely limit the quality of station placement, especially if specific, local knowledge of the area and its access routes are not previously known by the field crew. Selecting sites from an office based on maps or satellite images also has limitations. Access and potentially dangerous conditions such as avalanche paths can be overlooked. Some combination of selecting a few potential sites via maps followed by field scouting prior to the day of station establishment will likely prove extremely valuable.

We established stations in February and March this year when snow conditions are typically better for snowmobiling and hours of daylight are increasing. Establishing stations during early winter in fresh, powdery snow will likely prove more difficult and time-consuming at the time of year when daylight is most limited. Furthermore, the winter of 2014-15 recorded below average snowpack until spring storms hit in May. This allowed quicker access to backcountry wilderness sites that could prove inaccessible in an average or above average snow year.

Bait and Scent Lures

When determining bait station placement, it may be prudent to consider the amount of bait that can feasibly be transported to the site. Our station checks showed that marten and other non-target species can remove all meat from a single deer hindquarter in under 14 days. During our first winter of surveys, only sites that had been rebaited detected wolverines. Furthermore, latency times between baiting (initial baiting or rebaiting) and the first wolverine detection at a site was never more than 16 days (Table 2). Based on these observations, larger volumes of bait, that are less likely to be depleted between checks, may be important in garnering initial wolverine detections. We believe this factor to potentially have such a great influence that it may be helpful to consider dropping an entire deer carcass from aircraft at sites where a carcass cannot be brought in via snowmobile or ski. A carcass attracts other animals such as ravens, coyotes, etc., and their presence begins radiating the scent of the bait over a larger area. Noise from birds at the site may also aid wolverines in locating the site. Long-distance scent lure such as pure beaver castor or rotten blood is essential and can be mixed with petroleum jelly to prolong effectiveness.

Causes of Ineffective Sampling Periods

While our initial plans called for deploying stations starting in January, expenditure of funds was not possible until early March. This resulted in the use of several older model Reconyx cameras (RC60, PC85) early in the effort. These cameras required NiMH batteries, and they failed quickly, causing several days of ineffective sampling. Six stations had eight periods of ineffective sampling due to battery failure (n=6) or bear displacement of the camera (n=3). It is worth noting, however, that four of these six stations detected wolverines despite periods of ineffective sampling of up to 72 days. Later model cameras with energizer lithium ultra batteries did not fail and used very little capacity even with thousands of photos. Use of cameras that can utilize lithium batteries is essential for success.

In instances of ineffective sampling due to bears, cameras were either moved such that they were oriented away from the bait/scent or opened. After encountering the problem posed by bears, we purchased metal boxes for all cameras. These boxes were installed at each site during the last recheck prior to the summer sampling effort. These boxes are attached to the tree with four lag bolts, and the box is pad-locked to prevent entry and opening of the camera. These boxes should nearly eliminate movement/opening of the cameras by bears or humans.

Camera Problems

Despite obtaining photos of W0001 standing on a Magoun run-pole and frame, photo resolution was lacking for confident sex ID. Camera placement and settings play a large part in image quality. Cameras should be set in forested areas, facing north whenever possible to reduce backlighting. Cameras should also be programmed with balanced contrast, sharpness, and saturation while night shutter speed should be fast and night ISO sensitivity low (Magoun, personal communication, Appendix 4). While these settings can be programmed ahead of time using Reconyx's Professional Settings software, night mode must be set to "high quality" in the camera's setup menu at the time that each camera is armed.

In the case of the images of W0001 standing, the above steps were taken to maximize image quality, yet resolution was still poor. We used a Reconyx PC850 with white flash capability at this site and the flash did not go off, despite the low light conditions the morning the wolverine was photographed. After conferring with Reconyx and other biologists with experience camera trapping wolverines, we believe small adjustments to camera setup should improve image quality such that determining sex and reproductive status should be possible (see "Recommendations" below).

Method for Obtaining Genetic Samples

Between the two hair snare methods we used, alligator clips were easier to use than barbed wire. Alligator clips on a Magoun run-pole and frame are simpler to check for samples and sterilize than barbed wire, given their concentration in a smaller area. Furthermore, alligator clips set high above the ground are less likely to snare hair from common non-target species such as fox and coyotes. Finally, in some cases, camera trap photos may reveal which alligator clips have fired during a wolverine visit, decreasing the cost of DNA analysis by winnowing out samples from non-target species. Resetting alligator clips in the field takes about 5 minutes. On the other hand, clips are limited to the number of samples they can collect, (i.e., 1 per clip). If all clips are triggered and fall prior to a wolverine visit, there is no chance for obtaining wolverine DNA. Clevenger and Barrueto (2014) had good success using barbed wire. Testing the successful amplification ability of different DNA capture devices (barbed wire, alligator clips, gun brushes) by their either “plucking” or “combing” a hair sample (potentially with or without a root) would provide important information.

Recommendations

To address wolverine occupancy, we recommend scouting and deploying stations during November followed by rechecking stations once a month during December, January, February, and March. Bait should first be supplied in November, under guidance of bear biologists, then replenished in December, January, and February. If cameras deployed during summer 2015 reveal that detection of wolverines or reproductive events can be improved with total time operating, leaving cameras out with scent lure only all summer with a final removal during fall may prove worthwhile. We recommend baiting with a deer carcass wired to the base of a tree on the ground, although as much of the carcass as possible should be wired to a branch higher up the tree to the keep bait out of frame of the camera and out of reach of canid scavengers. Deer carcasses transported by snowmobile should be dragged to the site to create a scent trail. Where necessary, deer carcasses should be dropped from aircraft at sites with limited snowmobile access to increase the quantity of bait available to attract wolverines. Gun brushes should be attached around the tree trunk as hair snags for DNA samples. Cameras should be set within 2–4m of the bait tree at a height sufficient to avoid being covered by fresh snow, but low enough to photograph animals approaching the base of the bait tree on the ground. Use of lithium batteries is essential, and sturdy metal boxes are needed to limit or eliminate interference by bears. We recommend using Reconyx’s Professional Settings software to pre-program camera memory cards. This software programs numerous important settings including sensor sensitivity, pictures per trigger, delay between pictures, and quiet period (interval between triggers). Unbiased results are dependent on having these settings standardized among stations, and preprogrammed memory cards are the best way to ensure that each of these settings are the same each time.

Differing settings will also influence the total number of pictures that are made and subsequently reviewed and cataloged. Aggressive settings can result in hundreds of thousands of additional photos to check for wolverine presence. The vast majority of these photos will be of non-target species and sorting through them will add significant personnel costs. Insufficient memory on some computers when storing photos of non-target species may also be an issue. We recommend programming cameras to take 5 pictures per trigger, with no delay, and a 15-second quiet period between triggers. For data management, we recommend use of a no-cost software developed by Colorado Parks and Wildlife to tag photos, create a database, sort into modules that can be delivered to and examined by individuals, and generate reports (Newkirk 2014).

For managers interested in addressing presence of reproductive female wolverines, we recommend deploying run-poles and frames at sites where wolverines have already been detected. This can be done at sites where methodology for determining wolverine occupancy is in use by deploying a second, white flash camera. This camera should be oriented towards the newly established run-pole and frame. Bait should be suspended approximately 30–40cm above the top of the frame. Several steps can be taken to mitigate problems of poor image quality that hampered sex and reproductive status ID during sampling this winter. First, photo resolution should be considered when determining the distance between the camera trap and bait tree or run-pole. Where cameras with greater resolution and a more powerful flash (e.g. Trail Watcher) may be set 3–4 m from a run-pole and still generate images of sufficient quality to identify sex and reproductive status of wolverines (Magoun et al. 2011), Reconyx PC850 cameras should be set closer to the run-pole (~1.5 m) at sites where sex or reproductive status IDs are desired.

Covering light sensors on white-flash cameras should also improve image quality by causing the flash to fire every time the camera is triggered.

Tables

Table 1. Summary of station information related to wolverine detection efforts in northwestern Wyoming, February-June 2015.

Station	Grid Cell	Mtn. Range	Elev. (m)	Site Visits	Days Camera Operational	Days Camera Nonoperational	Total Photos	Wolverine Photos	Wolverine Visits[1]	DNA Samples
Emigrant	321	Salt/Wyoming	2,395	3	100	-	1,715	0	-	7
Sheep Pass	324	Salt/Wyoming	2,924	3	105	-	1,645	0	-	2
Stough Creek	333	Wind River	2,893	2	11	95	109	0	-	0
Mary's Lake	340	Wind River	2,852	2	120	-	4,451	0	-	0
Dishpan Butte	341	Wind River	3,107	2	97	-	2,163	0	-	0
Murphy Lake	342	Salt/Wyoming	2,137	3	76	-	115	0	-	0
Greyback Ridge	352	Salt/Wyoming	2,243	3	96	-	3,450	0	-	7
Crow Mountain	357	Wind River	2,946	2	103	-	2,238	0	-	0
Tosi Creek	366	Gros Ventre	2,913	4	104	14	18,100	326	9	11
Clear Creek	368	Wind River	2,528	3	39	72	1,110	122	3	7
Burro Flat	379	Wind River	3,184	3	52	67	10,159	365	5	2
Moon Lake	390	Wind River	2,941	4	87	22	958	151	5	4
Bonneville Pass	424	Absaroka	3,057	5	135	-	14,424	7,249	31	7
Deacon Lake	425	Absaroka	3,048	3	118	-	4,684	0	-	8
Wiggins Fork	426	Absaroka	2,668	3	88	25	1,315	0	-	7
Sunlight Basin	549	Absaroka	2,311	2	93	-	1,955	0	-	2
Jim Mountain	550	Absaroka	2,738	2	93	-	1,210	0	-	1
Pilot Creek	601	Absaroka	2,435	2	100	-	235	0	-	0
		TOTAL		**51**	**1,618**	**295**	**70,036**	**8,213**	**53**	**65**
		AVERAGE	**2,740**	**3**	**90**					

[1]Visit defined as the period a wolverine was photographed at a bait station with no absences >60 minutes.

Table 2. Dates and latency times of wolverine detections at camera stations during February-June 2015.

Grid Cell	Station Deployed	Station Last Baited	Wolverine Detected	Wolverine ID	DAYS UNTIL WOLVERINE DETECTION Since Deployment	Since Last Baited
424	9-Feb	9-Feb	25-Feb	W0001	16	16
424	9-Feb	9-Feb	26-Feb	W0001	17	17
424	9-Feb	9-Feb	27-Feb	W0001	18	18
424	9-Feb	9-Feb	28-Feb	W0001	19	19
424	9-Feb	9-Feb	1-Mar	W0001	20	20
424	9-Feb	9-Feb	2-Mar	W0001	21	21
424	9-Feb	9-Feb	3-Mar	W0001	22	22
424	9-Feb	9-Mar	14-Mar	Unknown	33	5
366	26-Feb	18-Mar	23-Mar	Unknown	25	5
368	4-Mar	18-Mar	31-Mar	Unknown	27	13
366	26-Feb	1-Apr	2-Apr	Unknown	35	1
366	26-Feb	1-Apr	3-Apr	Unknown	36	2
368	4-Mar	18-Mar	3-Apr	Unknown	30	16
424	9-Feb	10-Apr	15-Apr	W0001	65	5
390	25-Feb	10-Apr	17-Apr	Unknown	51	7
379	27-Feb	4-Apr	18-Apr	Unknown	50	14
390	25-Feb	10-Apr	18-Apr	Unknown	52	8
379	27-Feb	4-Apr	19-Apr	Unknown	51	15
424	9-Feb	10-Apr	27-Apr	Unknown	77	17
366	26-Feb	1-Apr	1-May	Unknown	64	30
366	26-Feb	1-Apr	2-May	Unknown	65	31
366	26-Feb	1-Apr	3-May	Unknown	66	32
424	9-Feb	10-Apr	6-Jun	white forelimbs	117	57

Rows shaded gray denote first wolverine detection at each of the five grid cells where detections occurred.

Table 3. Occupancy models tested with data from sampling effort in northwestern Wyoming during February-June, 2015.

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	-2log(L)
{p(.) psi}	46.6269	0	0.29122	1	2	41.7039
{p(.) psi(elevation)}	46.6982	0.0713	0.28102	0.965	3	38.6982
{Royle Nichols}	46.7474	0.1205	0.27419	0.9415	2	41.8244
{p(elevation) psi(.)}	49.1212	2.4943	0.08367	0.2873	3	41.1212
{p(elevation) psi(elevation)}	49.5781	2.9512	0.06658	0.2286	4	37.9417

Table 4. Non-target mammal species detected by camera traps, February-June 2015.

Common Name	**Scientific Name**	**Grid Cells Detected at**
Yellow-bellied marmot	*Marmota flaviventris*	1
Ground squirrel	*Spermophilis sp.*	1
Northern flying squirrel	*Glaucomys sabrinus*	1
Red squirrel	*Tamiasciurus hudsonicus*	11
Snowshoe hare	*Lepus americanus*	7
Mule deer	*Odocoileus hemionus*	10
Elk	*Cervus elaphus*	9
Moose	*Alces alces*	2
Pronghorn	*Antilocapra americana*	1
Bighorn sheep	*Ovis canadensis*	2
Bobcat	*Lynx rufus*	3
Mountain lion	*Puma concolor*	1
Coyote	*Canis latrans*	9
Red fox	*Vulpes vulpes*	12
Black bear	*Urus americanus*	11
Grizzly bear	*Ursus arctos*	4
American marten	*Martes americana*	15

Table 5. Non-target bird species detected by camera traps, February-June 2015.

Common Name	**Scientific Name**	**Grid Cells Detected at**
Golden eagle	*Aquila chrysaetos*	2
Stellar's jay	*Cyanocitta stelleri*	2
Gray jay	*Perisoreus canadensis*	6
Clark's nutcracker	*Nucifraga columbiana*	9
Black-billed magpie	*Pica hudsonia*	2
Common raven	*Corvus corax*	2
Black-capped chickadee	*Poecile atricapilla*	1
Mountain chickadee	*Poecile gambeli*	1

Supplemental Figures

Figure S1. Non-wilderness site with Magoun frame and barbed wire on tree.

Figure S2. Site with full deer carcass.

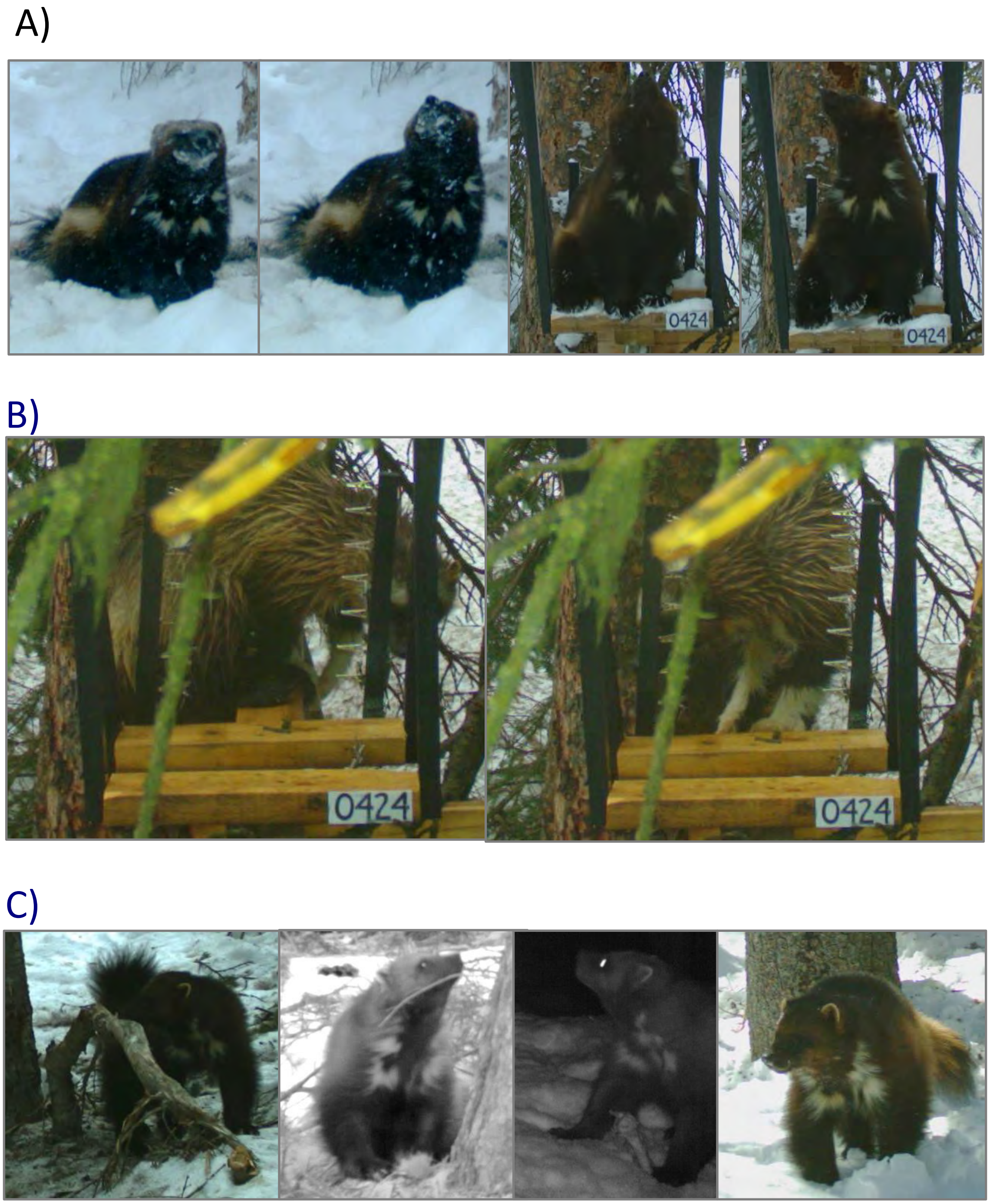


Figure S3. A) Photos of ventral markings of wolverine W0001 at grid cell 424, B) white forelimbs on wolverine at grid cell 424, and C) ventral markings of wolverine(s) at grid cells 366, 368, 379, and 390, respectively; DNA samples may reveal the identity of one or more individuals.

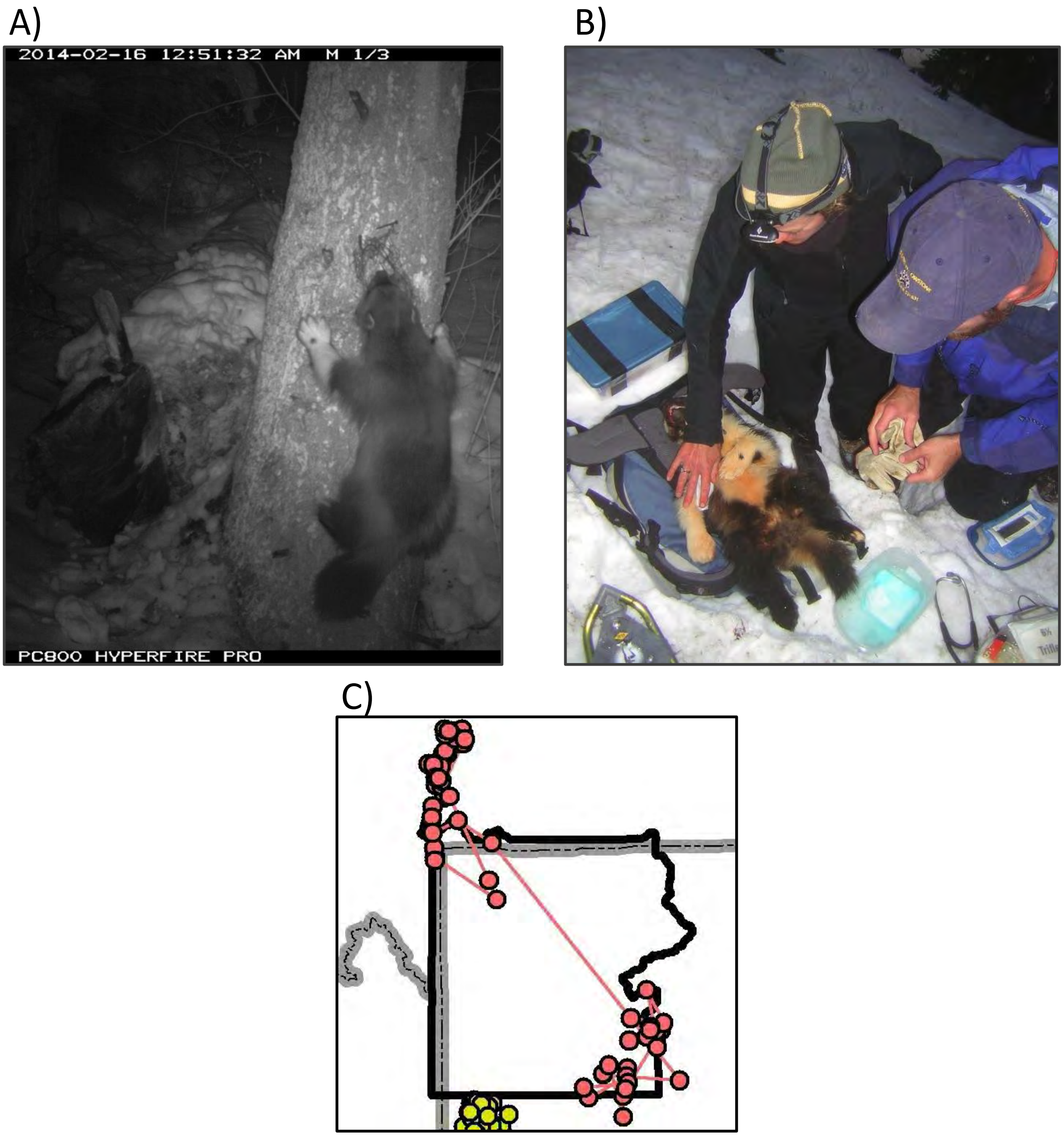


Figure S4. A) Photograph of a wolverine made in Fishhawk Creek in the Central Absarokas by Jesse Boulerice of Wyoming Game and Fish during winter 2013-14 surveys for fisher. B) Photograph of F133 at her 2006 capture as a juvenile at a den site in the Gallatin Range of southwestern Montana (note large areas of white on forelimbs and distinctive brown spot on left front paw). C) Locations of F133 (pink) during her dispersal into southeastern Yellowstone National Park during 2007.

Literature Cited

Anderson, N.J. and K.E. Aune. 2008. Fecundity of female wolverine in Montana. Intermountain Journal of Science 14 (1-3):17-30.

Aubry, K.B., K.S. McKelvey, and J.P. Copeland. 2007. Distribution and broadscale habitat relations of the wolverine in the contiguous United States. Journal of Wildlife Management 71: 2147-2158.

Aubry, K.B., J. Rohrer, C.M. Raley, R.D. Weir, and S. Fitkin. 2012. Wolverine distribution and ecology in the North Cascades Ecosystem, 2012 Annual Report. U.S. Forest Service, Pacific Northwest Research Station, Olympia, Washington, USA.

Cegelski, C.C., L.P. Waits, N.J. Anderson, O. Flagstad, C. Strobeck, and C.J. Kyle. 2006. Genetic diversity and populations structure of wolverine (*Gulo gulo*) populations at the southern edge of their current distribution in North America with implications for genetic viability. Conservation Genetics 7:197-211.

Clevenger, A.P., and M. Barrueto. 2014. Trans-Canada Highway Wildlife and Monitoring Research, Final Report, Part B: Research. Prepared for Parks Canada Agency, Radium Hot Springs, British Columbia.

Copeland, J.P. 1996. Biology of the wolverine in central Idaho. M.S. Thesis, University of Idaho, Moscow, USA.

Copeland, J.P., Yates, R.E., 2008. Wolverine Population Assessment in Glacier National Park. General Technical Report. USDA Forest Service, Rocky Mountain Research Station, Missoula, Montana, USA.

Fisher, J.T., S. Bradbury, B. Anholt, L. Nolan, L. Roy, J.P. Volpe, and M. Wheatley. 2013. Wolverines on the Rocky Mountain slopes: natural heterogeneity and landscape alteration as predictors of distribution. Canadian J. Zoology 91:706-716.

Golden, H.N., J.D. Henry, E.F. Becker, M.I. Goldstein, J.M. Morton, D. Frost, Sr., and A.J. Poe. 2007. Estimating wolverine (*Gulo gulo*) population size using quadrat sampling of tracks in snow. Wildlife Biology 13 (Suppl. 2):52-61.

Hornocker, M.G., and H.S. Hash. 1981. Ecology of the wolverine in Northwestern Montana. Canadian J. Zoology 59:1286–1301.

Idaho Department of Fish and Game. 2014. Management plan for the conservation of wolverines in Idaho. Idaho Department of Fish and Game, Boise, Idaho, USA.

Inman, R.M., R.R. Wigglesworth, K.H. Inman, M.K. Schwartz, B.L. Brock, and J.D. Rieck. 2004. Wolverine makes extensive movements in the Greater Yellowstone Ecosystem. Northwest Science. 78: 261-266.

Inman, R.M., K.H. Inman, M.L. Packila, and A.J. McCue. 2007. Wolverine reproductive rates and maternal habitat in Greater Yellowstone. Chapter 4 in Greater Yellowstone Wolverine Study, Cumulative Report, May 2007. Wildlife Conservation Society, North America Program, General Technical Report, Bozeman, Montana, USA.

Inman, R.M., M.L. Packila, K.H. Inman, A.J. McCue, G.C. White, J. Persson, B.C. Aber, M.L. Orme, K.L. Alt, S.L. Cain, J.A. Fredrick, B.J. Oakleaf, and S.S. Sartorius. 2012. Spatial Ecology of wolverines at the southern periphery of distribution. Journal of Wildlife Management 76:778-792.

Inman, R.M., B.L. Brock, K.H. Inman, S.S. Sartorius, B.C. Aber, B. Giddings, S.L. Cain, M.L. Orme, J.A. Fredrick, B.J. Oakleaf, K.L. Alt, E. Odell, and G. Chapron. 2013. Developing priorities for metapopulation conservation at the landscape scale: Wolverines in the Western United States. Biological Conservation 166:276-286.

Kincaid, T.M. and A.R. Olsen. 2011. spsurvey: Spatial Survey Design and Analysis. R package version 2.2.

Landa, A., O. Strand, J.D.C. Linell, and T. Skogland. 1998. Home range sizes and altitude selection for arctic foxes and wolverines in an alpine environment. Canadian Journal of Zoology 76:448–457.

MacKenzie, D., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inference methods for patterns and dynamics of species occupancy. Elsevier,

Inc., San Diego, California, USA.
Mackenzie, D. I., J. D. Nichols, M. E. Seamans, and R. J. Gutierrez. 2009. Modeling species occurrence dynamics with multiple states and imperfect detection. Ecology 90:823–835.
Magoun, A.J. 1985. Population characteristics, ecology and management of wolverines in northwestern Alaska. Dissertation, University of Alaska, Fairbanks, USA.
Magoun, A.J., C.D. Long, M.K. Schwartz, K.L. Pilgrim, R.E. Lowell, and P. Valkenburg. 2011. Integrating motion-detection cameras and hair snags for wolverine identification. Journal of Wildlife Management 75:731-739.
Magoun, A.J., P. Valkenburg, C.D. Long, and J.K. Long. 2013. Monitoring Wolverines in Northeast Oregon. January 2011 – December 2012. Final Report. The Wolverine Foundation, Inc., Kuna, Idaho, USA.
Murphy, K., J. Wilmot, J. Copeland, D. Tyers, J. Squires, R.M. Inman, M.L. Packila, and D. McWhirter. 2011. Wolverine conservation in Yellowstone National Park: Final report. YCR-2011-02. National Park Service, Yellowstone National Park, Yellowstone Center for Resources, Yellowstone National Park, Wyoming.
Newby, F.E., and P.L. Wright. 1955. Distribution and status of the wolverine in Montana. Journal of Mammalogy 36(2):248–253.
Newby, F.E., and J.J. McDougal. 1964. Range extension of the wolverine in Montana. Journal of Mammalogy 45:485-486.
Newkirk, E.S. 2014. CPW Photo Warehouse. Colorado Parks and Wildlife, Fort Collins, Colorado, USA. http://cpw.state.co.us.learn/Pages/ResearchMammals.aspx.
Persson, J., P. Wedholm, and P. Segerström. 2010. Space use and territoriality of wolverines (*Gulo gulo*) in northern Scandinavia. European Journal of Wildlife Research 56:49-57.
Persson, J., A. Landa, R. Andersen, P. Segerström. 2006. Reproductive characteristics of female wolverines (*Gulo gulo*) in Scandinavia. Journal of Mammalogy 87:75–79.
Schwartz, M.K., J.P. Copeland, N.J. Anderson, J.R. Squires, R.M. Inman, K.S. McKelvey, K.L. Pilgrim, L.P. Waits, and S.A. Cushman. 2009. Wolverine gene flow across a narrow climatic niche. Ecology 90(11):3222-3232.
Squires, J.R., Copeland, J.P., Ulizio, T.J., Schwartz, M.K., Ruggiero, L.F., 2007. Sources and patterns of wolverine mortality in western Montana. J. Wildl. Manage. 71 (7), 2213–2220.
United States Fish and Wildlife Service [USFWS]. 2013a. Endangered and Threatened Wildlife and Plants; Threatened Status for the Distinct Population Segment of the North American Wolverine Occurring in the Contiguous United States; Establishment of a Nonessential Experimental Population of the North American Wolverine in Colorado, Wyoming, and New Mexico; Proposed Rules. Federal Register Vol. 78, No. 23, Monday, February 4, 2013. 7864–7890.
United States Fish and Wildlife Service [USFWS]. 2013b. Draft Recovery Outline, North American Wolverine (*Gulo gulo luscus*) Contiguous United States Distinct Population Segment. Montana Ecological Field Services Office.
Vangen, K. M., J. Persson, A. Landa, R. Andersen, and P. Segerström. 2001. Characteristics of dispersal in wolverines. Canadian Journal Zoology 79:1641–1649.
Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan - 2010. Wyoming Game and Fish Department, Cheyenne, USA.

Appendices

Appendix 1. Examples of general bait station locations that detected wolverines.

Clear Creek, Wind River Range (cell 368)

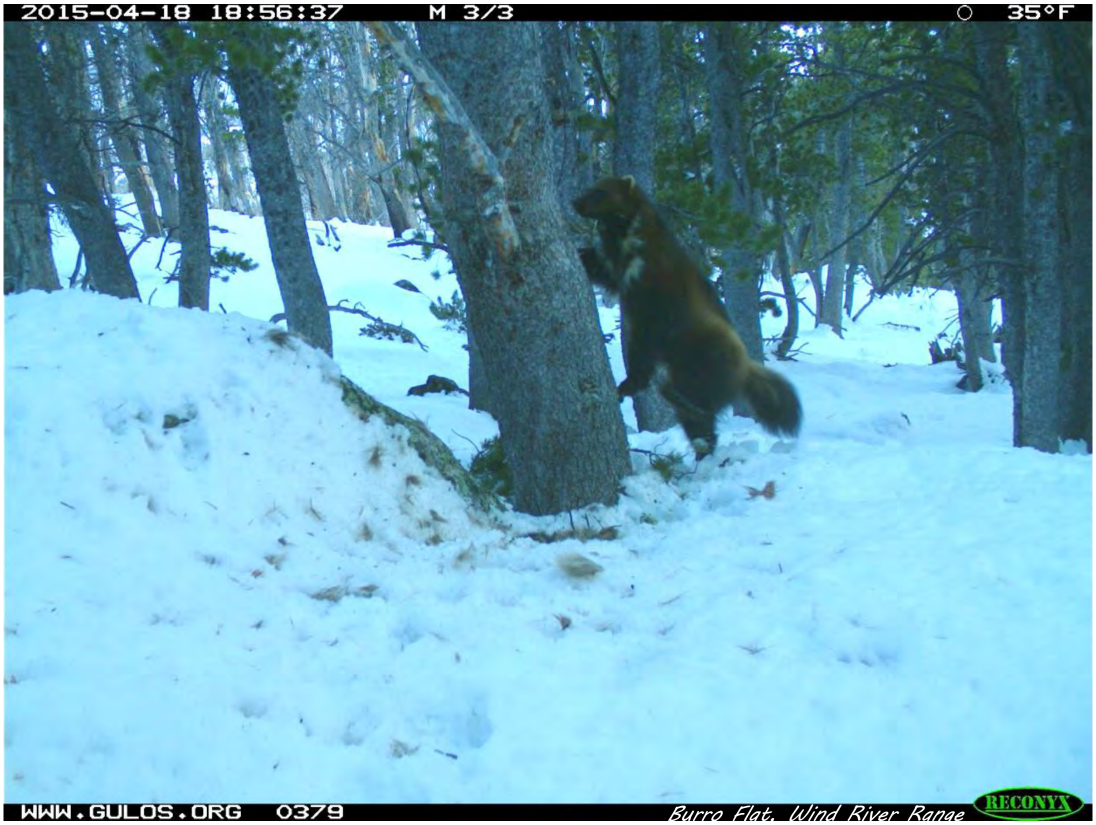
Burro Flat, Wind River Range (cell 379)

Bonneville Pass, Southern Absaroka Range (cell 424)

Appendix 2. Photographs of wolverines detected at bait stations in northwest Wyoming during winter and spring, 2014-15. Bait station IDs appear at bottom of each photo.


2015-04-03 12:32:30 M 2/5 25°F
WWW.GULOS.ORG 0368
Clear Creek, Wind River Range
RECONYX


2015-04-03 18:54:38 M 4/5 31°F
WWW.GULOS.ORG 0368
Clear Creek, Wind River Range
RECONYX


2015-04-18 18:56:37
M 3/3
35°F
WWW.GULOS.ORG 0379
Burro Flat, Wind River Range
RECONYX


2015-04-18 21:32:27
M 1/3
32°F
WWW.GULOS.ORG 0379
Burro Flat, Wind River Range
RECONYX


2015-04-17 10:44:32
M 1/3
41°F
WWW.GULOS.ORG
0390
Moon Lake, Wind River Range
RECONYX


2015-04-17 18:06:22
M 1/3
43°F
WWW.GULOS.ORG
0390
Moon Lake, Wind River Range
RECONYX


2015-04-15 08:32:43
M 2/3
18°F
WWW.GULOS.ORG 0424
Bonneville Pass, Southern Absarokas
RECONYX


2015-06-06 17:47:15
M 3/3
42°F
0424
WWW.GULOS.ORG 0424
Bonneville Pass, Southern Absarokas
RECONYX

Appendix 3. Photographs of a few incidental mammal and bird species detected at bait stations.

Northern flying squirrel

Pronghorn

Bobcat

Mountain lion

Black bear

Grizzly bear

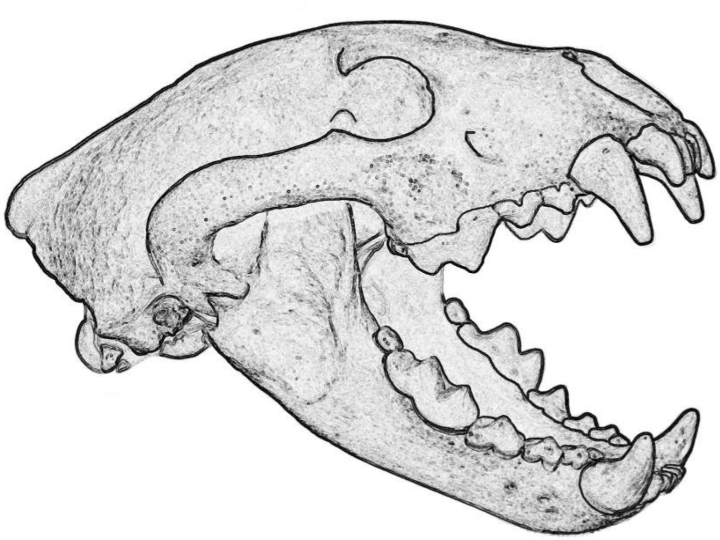
American marten

Golden eagle

Appendix 4. Reconyx PC800 camera settings.

Change Setup
- Advanced
  - Triggers Tab
    - Quickset = Advanced
    - Motion Sensor = On
    - Sensitivity = High
    - Pics/Trigger = 5
    - Picture Interval = No Delay
    - Quiet Period = 15 seconds
  - Time Lapse Tab
    - Off
  - Images Tab
    - Label = cell number
    - Brightness = 5th or mid.
    - Contrast = 5th or mid
    - Sharpness = 5th or mid
    - Saturation = 5th or mid
    - Fahrenheit, 24 hr
    - Night Shutter Speed = Fast
    - Night ISO Sensitivity = Low
    - Resolution = High
    - No border
  - Cellular Tab
    - N/A
  - Other Tab
    - Code Loc = 3334

Other if applicable:
Resolution = 3.1MP, High
Night Mode = High Quality, Illuminator = On



WOLVERINE (*Gulo gulo*)

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HARVEST REPORTS

HARVEST OF RAPTORS FOR FALCONRY

STATE OF WYOMING

NONGAME BIRDS: Raptors

FUNDING SOURCE: Wyoming Game and Fish Department
Bureau of Land Management Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2015 – 31 December 2015

PREPARED BY: Courtney Rudd, Nongame Biologist
Brooke Weaver, Game Warden Trainee

SUMMARY

In 2015, the Wyoming Game and Fish Department issued 41 falconry capture licenses. The number of licenses issued represented an increase from 2014 (n = 27 licenses), but is the same as the number issued in 2012. Licenses were issued for 23 residents and 18 nonresidents. Residents filled 11 of 23 licenses; nonresidents filled 1 of 18 licenses. Although only 2 Red-tailed Hawks (*Buteo jamaicensis*) were captured in 2014, it was the most commonly captured species during 2015, with 6 captures (2 female, 1 male, 3 unknown) taken by residents and the remaining capture (1 female) taken by a nonresident. Although the Prairie Falcon (*Falco mexicanus)* was the most commonly captured species in 2014, only 1 male was captured by a resident in 2015. Two Peregrine Falcons (*Falco peregrines*; 1 female, 1 unknown) were captured by a resident. A single female Northern Goshawk (*Accipiter gentilis*) and a single female Cooper's Hawk (*Accipiter cooperii*) were each captured by the same resident (Table 1). The total number of birds captured in 2015 (n = 12) was substantially less than the mean (±SE) number of captures from 1981-2014 (22.1 ± 1.49 birds). Additionally, capture success for 2015 (29%) was less than the mean (±SE) capture success from 1981-2014 (46.3% ± 2.17%, Table 2).

Table 1. Species and number of raptors captured by residents and nonresidents for falconry in Wyoming, 2015.

Species captured	Number of resident captures	Number of nonresident captures	Total captures
Cooper's Hawk	1	0	1
Northern Goshawk	1	0	1
Red-tailed Hawk	6	1	7
Peregrine Falcon	2	0	2
Prairie Falcon	1	0	1
Total	11	1	12

Table 2. Number of individuals captured and yearly capture success rate (%) for raptors taken for falconry in Wyoming, 1981-2015.

Year	Number of raptors captured	Capture success rate (%)
1981	27	37
1982	40	52
1983	18	18
1984	25	33
1985	39	53
1986	33	35
1987	19	36
1988	28	51
1989	26	55
1990	32	68
1991	29	66
1992	22	53
1993	13	37
1994	21	33
1995	12	30
1996	25	47
1997	19	61
1998	31	63
1999	27	55
2000	24	57
2001	21	45
2002	29	58
2003	21	49
2004	33	48
2005	13	31
2006	14	40
2007	15	45
2008	27	69
2009	8	53
2010	5	26
2011	15	50
2012	20	49
2013	10	30
2014	11	41
2015	12	29

OTHER NONGAME – BIRDS

USING THE BREEDING BIRD SURVEY TO MONITOR POPULATION TRENDS OF AVIAN SPECIES IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Other Nongame

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Bureau of Land Management Cooperative Agreement
Bureau of Reclamation Cooperative Agreement
National Park Service Cooperative Agreement
United States Fish and Wildlife Service Cooperative Agreement
United States Forest Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Courtney Rudd, Nongame Biologist
Andrea Orabona, Nongame Bird Biologist
Unites States Geological Survey – Biological Resources Division

ABSTRACT

The Breeding Bird Survey has provided long-term monitoring of a variety of avian species in Wyoming since 1968. In 2014, volunteers surveyed 65 Breeding Bird Survey routes across the state. Overall, survey effort and number of detections per survey route have decreased, while the number of species detected per route has increased. Recruiting knowledgeable volunteers to conduct Breeding Bird Survey routes is critical to ensuring the success of the Breeding Bird Survey and our ability to continue to monitor populations of breeding birds along roadside surveys.

INTRODUCTION

Fifty-six avian species are classified as Species of Greatest Conservation Need (SGCN) by the Wyoming Game and Fish Department (Department; WGFD 2010). The Department utilizes data from various large-scale, multi-species survey efforts to monitor trends in avian populations, while implementing species-specific surveys for those species that are not adequately monitoring using the multi-species survey methods.

The Breeding Bird Survey (BBS) is used to monitor trends of breeding birds across North America. The BBS is sponsored jointly by the United States Geological Survey – Biological Resources Division (USGS-BRD; formerly the US Fish and Wildlife Service [USFWS]) and the Canadian Wildlife Service. This roadside survey methodology was field tested in 1965 and formally launched in 1966, with 600 routes established in the US east of the Mississippi River and in Canada(Sauer et al. 1997). In 1967, the BBS spread to the Great Plains States and Prairie Provinces. By 1968, approximately 2,000 BBS routes were set up across southern Canada and the contiguous 48 states, and more than 1,000 routes were surveyed annually. During the 1980s, the BBS expanded further into Alaska and Canada's Yukon and Northwest Territories, and additional routes were added in many states. Today, over 4,500 BBS routes are located across the continental US and Canada, including 108 active routes in Wyoming (Figure 1).

The BBS was designed to provide a continent-wide perspective of population change. All routes have been randomly located in order to sample habitats that are representative of the entire region. Other requirements, such as consistent methodology, observer expertise, visiting the same stops each year, and conducting surveys under suitable weather conditions, are necessary to produce comparable data over time (Sauer et al. 1997). A large sample size (i.e., number of routes conducted) is needed to average local variations and reduce the effects of sampling error (i.e., variation in counts attributable to both sampling technique and real variation in trends).

The BBS provides an index of relative abundance rather than a complete count of breeding bird populations. Data can be used to estimate population trends and relative abundance of individual species at the continental, regional, statewide, and physiographic region scale. Relative abundance maps should be viewed with some caution, however, as species tend to be rare, locally distributed, and likely to be poorly represented along BBS routes at the edges of their ranges (Sauer et al. 1997). The most effective use of BBS data is to analyze population change on survey routes; however, these data do not provide an explanation for the causes of population trends. To evaluate population changes over time, BBS indices from individual routes are combined to acquire regional and continental estimates of trends (Sauer et al. 1997). Some species have consistent trends throughout the history of the BBS, although most do not due to stochastic effects that can affect populations.

Our objectives in 2014 were to add additional data to the BBS and interpret current large-scale trends of nongame breeding birds in Wyoming. While 2014 and 2015 population trend estimates were not completed by publication time, said analyses are available through 2013 for over 420 species of birds and, for the purposes of this report, were reviewed for SGCN only (Sauer et al. 2014). All raw data can be accessed on the BBS web site http://www.pwrc.usgs.gov/bbs/ (Pardieck et al. 2015).

METHODS

Volunteers are instructed to conduct BBS routes during the height of the avian breeding season when birds are most vocal. This is typically during the month of June, although routes in higher elevations can be conducted through the first week of July. Each route is 39.4 km long and consists of 50 stops spaced at 0.8 km intervals along the route. Beginning 0.5 hour before sunrise, observers record birds seen within a 0.4 km radius and all birds heard at each stop during a 3-minute count period. Each route is surveyed once annually, and data are submitted to the USGS-BRD for analysis. For all summary statistics on survey effort, we report averages ±SE. All analyses on abundance of breeding birds in Wyoming were conducted by USGS-BRD.

RESULTS

In 2014, observers surveyed approximately 2,516 of 3,538 (71 %) active routes in the US. In Wyoming, observers surveyed 65 of the 108 (60%) active routes. Results are reported in Table 1. Since 1990, the number of routes surveyed in Wyoming has decreased by 0.73 routes per year (P<0.001; R^2=0.4997; Figure 2). Consistent with this trend, the number of routes surveyed in 2014 (i.e., 65 routes) was equal to the mean number of routes completed from 1990-2013 (65.0 ±1.59 routes).

Observers detected a total of 32,668 individual birds representing 191 species in Wyoming (Table 2). Since 1990, the number of individuals detected has decreased by 5.0 individuals per route per year (P<0.001; R^2=0.6022; Figure 3), but the number of species detected has increased by 0.14 species per route per year (P<0.001; R^2=0.3856; Figure 4). Consistent with these trends, the number of individuals detected per route in 2014 (i.e., 501.2 ±40.0 individuals) was less than the mean number of individuals detected per route between 1990–2013 (i.e., 529.6 ±9.7 individuals), and the number of species detected per route (i.e., 36.6 ±1.6 species) was slightly less than the mean number of species detected per route between 1990-2013 (i.e., 38.1 ±0.3 species).

Of the 191 species detected in 2014, 32 are SGCN. Of this latter total, 6 have sufficient data for trend analysis from 1968-2013 (Figures 2-4) and includes Brewer's Sparrow (*Spizella breweri*), Grasshopper Sparrow (*Ammodramus savannarum*), and Sage Thrasher (*Oreoscoptes montanus*), which display stable populations; Greater Sandhill Crane (*Grus canadensis tabida*) and Sagebrush Sparrow (*Artemisiospiza nevadensis*), which display increasing populations; and Lark Bunting (*Calamospiza melanocorys*), which displays a decreasing population. Of the 3 SGCN for which the USGS-BRD can determine a directional trend (Tables 4-5), only 1 species differs from nation-wide trends: Sagebrush Sparrow is increasing in Wyoming but decreasing nationwide.

DISCUSSION

A complete history of BBS observers and routes surveyed in Wyoming from 1968-2014 is available from the Department's Nongame Bird Biologist in the Lander Regional Office. Because the primary purpose of the BBS is to monitor population trends of avian species nationwide, it is important that each route is conducted annually, preferably by the same observer. However, in Wyoming fewer than 20 of the 108 total routes have been surveyed annually or with minimal interruptions in the annual survey cycle for >10 years. Most routes contain gaps in surveys of ≥2 years or have had ≥2 observers. There are several causes of BBS observer disruption: change in location or job duties during the course of an observer's career, loss of observers as they age and have increasing difficulty detecting vocalizations, and a limited pool of new and skillful observers in Wyoming from which to draw. In addition, as the degree of urbanization steadily increases, associated problems with safety and noise are an issue on some BBS routes. To address these problems, dangerous routes have been altered or are no longer conducted, although data gathered from progressively urbanized routes are important for the BBS's ability to measure changes on the landscape that birds are experiencing.

Overall, survey effort has decreased in the last 25 years. While 2014 recorded the 9^{th} lowest number of routes completed since 1990, at 65 routes, this was an increase of 5 routes from 2013, keeping Wyoming in the 51-75% completion bracket. While the number of individual birds detected per route has decreased steadily, the number of species detected per route has slightly increased over time. This increase in number of species per route is interesting, and may represent changes in species distributions or increases in identification skills of observers over time.

The UGSG-BRD has sufficient data to develop population trends for 6 avian SGCN in Wyoming; 3 of these species demonstrate stable trends, including Brewer's Sparrow, Grasshopper Sparrow, and Sage Thrasher; while 2 species, Greater Sandhill Crane and Sagebrush Sparrow, demonstrate increasing populations. The single species demonstrating a declining population, Lark Bunting, is associated with grasslands. This habitat is at high risk for degradation, alteration, or loss, and is listed among the most imperiled habitats in the US (WYPIF 2002, WGFD 2010). Sagebrush habitats are also increasingly threatened by habitat modification, and are often recognized as the limiting factor for sagebrush-obligate species (WGFD 2010). Consequently, this increase in Sagebrush Sparrows, in addition to continued stable populations of other sagebrush-obligate SGCN, including Brewer's Sparrows and Sage Thrashers, is promising.

The uses of BBS data are manifold. Trend data are used by the USFWS, Canadian Wildlife Service, and Partners in Flight to assess bird conservation priorities. Data were instrumental in focusing research and management actions on Neotropical migratory birds in the late 1980s, and on grassland birds in the mid-1990s. BBS data are used to help determine the need for SGCN status in State Wildlife Action Plans. State Natural Heritage programs and Breeding Bird Atlas projects use BBS data to enrich their databases. Data are used by educators as a tool to teach biological, statistical, and Geographic Information System concepts. Finally, BBS data have been used in over 450 scientific publications. Thus, the importance of recruiting and retaining qualified observers and ensuring that routes are conducted annually cannot be overstated.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature General Fund Appropriations, for which the Department is extremely grateful. We would like to thank the many volunteers and biologists from this and other natural resources management agencies for their valuable contributions to the 2014 Breeding Bird Survey (see names in Table 1). The continued dedication of these individuals and agencies to this monitoring effort makes it possible to collect long-term population trend data on numerous avian species in Wyoming.

LITERATURE CITED

Pardieck, K. L., D. J. Ziolkowski Jr., and M.-A. R. Hudson. 2015. North American Breeding Bird Survey dataset 1966-2014. Version 2014.0. US Geological Survey, Patuxent Wildlife Research Center, Maryland, USA.

Sauer, J. R., J. E. Hines, G. Gough, I. Thomas, and B. G. Peterjohn. 1997. The North American Breeding Bird Survey results and analysis. Version 96.4. Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski Jr., and W. A. Link. 2014. The North American Breeding Bird Survey, results and analysis 1966-2013. Version 01.30.2015. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State Wildlife Action Plan. Wyoming Game and Fish Department, Cheyenne, USA.

Wyoming Partners in Flight [WYPIF]. 2002. Growing Grassland Birds: Best Management Practices for Grasslands to Benefit Birds in Wyoming. Wyoming Game and Fish Department, Lander, USA.

Table 1. Latitudinal/longitudinal (latilong) degree block, observer, number of avian species detected, and number of individuals recorded for each Breeding Bird Survey route in Wyoming, 2014. Data are presented in numerical order by survey route. An asterisk indicates a deficiency is associated with a route (e.g., inclement weather, route conducted before or after the recommended survey window, private land access issues, lost data sheet, late start time).

Route number and name	Latilong	Observer	Species	Individuals
1 – NE Entrance, YNP*	1	John Parker	44	405
2 – Cody	2	Grace Nutting	47	399
3 – Otto	3	Rex Myers	45	635
4 – Basin	4	N/A – discontinued		
5 – Wyarno	5	John Berry	36	1188
6 – Clarkelen	6	N/A – discontinued		
7 – Sundance	7	Jennifer Adams	48	431
8 – Colter Bay	8	N/A – discontinued		
9 – Dubois	9	Jazmyn McDonald	59	454
10 – Midvale	10	Observer needed		
11 – Nowood	11	Donna Walgren	36	252
12 – Natrona	12	N/A – discontinued		
13 – Bill	13	Observer needed		
14 – Redbird	14	N/A – discontinued		
15 – Fontenelle	15	Carol Deno	Not conducted	Not conducted
16 – Elk Horn	16	Sid Johnson	Not conducted	Not conducted
17 – Bear Creek	17	Andrea Orabona	13	266
18 – Ervay	18	Jazmyn McDonald	40	255
19 – Brookhurst	19	Bruce Walgren	43	404
20 – Glenrock	20	N/A – discontinued		
21 – Dwyer	21	Martin Hicks	22	581
22 – Cumberland	22	Carol Deno	Not conducted	Not conducted
23 – McKinnon	23	N/A – discontinued		
24 – Patrick Draw	--	N/A – discontinued		
25 – Savery	25	Marie Adams	38	217
26 – Riverside*	26	Steve Loose	43	655
27 – Buford	27	Suzanne Fellows	Not conducted	Not conducted
28 – Yoder	28	Gloria Lawrence	48	1272
29 – Canyon	--	N/A – discontinued		
30 – Mammoth, YNP	1	Lisa Strait	48	377
31 – West Thumb	--	N/A – discontinued		
32 – Hunter Peak	2	Kathryn Hicks	Not conducted	Not conducted
33 – Clark	2	Suzy Grimes	33	415
34 – no route		N/A – no route		
35 – Frannie	3	Suzy Grimes	34	525
36 – Moose	8	Christine Paige	45	477
37 – Lovell	3	Observer needed		
38 – Meeteetse	3	Jazmyn McDonald	59	515
39 – Ten Sleep	4	C.J. Grimes	Not conducted	Not conducted

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
40 – Dayton	4	Tracey Ostheimer	53	515
41 – Bald Mountain	4	Observer needed		
42 – Crazy Woman	5	Grace Nutting	44	212
43 – Schoonover	5	Donald Brewer	17	589
44 – Arvada	5	Donald Brewer	26	505
45 – Recluse	6	Observer needed		
46 – Soda Well	6	Sandra Johnson	33	641
47 – Piney	--	N/A – discontinued		
48 – Seely	--	N/A – discontinued		
49 – Upton	7	Observer needed	Not conducted	Not conducted
50 – Moskee	--	N/A – discontinued		
51 – Alpine	8	Susan Patla	56	439
52 – Wilson	8	Observer needed		
53 – Horse Creek	9	Eva Crane	50	392
54 – no route		N/A – no route		
55 – Crowheart	9	James Downham	Not conducted	Not conducted
56 – Ethete	10	Joe Austin	44	600
57 – Anchor	10	Pat Hnilicka	Not conducted	Not conducted
58 – Gebo	10	Jazmyn McDonald	43	406
59 – Arminto	11	Heather O'Brien	25	406
60 – Lysite	11	Greg Anderson	Not conducted	Not conducted
61 – Worland	11	C.J. Grimes	Not conducted	Not conducted
62 – Teapot Dome	--	N/A – discontinued		
63 – Mayoworth	12	Observer needed		
64 – Sussex*	12	Bill Ostheimer	33	402
65 – Harland Flats	13	Observer needed		
66 – Pine Tree	13	Observer needed		
67 – Highlight	--	N/A – discontinued		
68 – Riverview	14	Nathan Darnall	31	515
69 – Newcastle	14	Observer needed		
70 – Raven	14	Nichole Cudworth	23	564
71 – Soda Lake	15	Observer needed		
72 – Buckskin Mountain	15	Don Delong	42	373
73 – Daniel	--	N/A – discontinued		
74 – Boulder	16	Susan Patla	Not conducted	Not conducted
75 – Big Sandy	16	Susan Patla	38	278
76 – Farson	16	Sid Johnson	Not conducted	Not conducted
77 – Fiddler Lake*	17	Eva Crane	46	268
78 – Sand Draw	17	Jazmyn McDonald	26	409
79 – Sweetwater	17	Stan Harter	Not conducted	Not conducted
80 – Gas Hills	18	N/A – discontinued		
81 – Bairoil	18	Greg Hiatt	26	354
82 – Lamont	18	Greg Hiatt	36	414

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
83 – Pathfinder	19	Laurie Schwieger	26	324
84 – Leo	19	Donna Walgren	31	260
85 – Shirley	19	Linda Drury	Not conducted	Not conducted
86 – Warbonnet*	20	Nathan Darnall	36	171
87 – Fletcher Peak	20	Gloria Lawrence	53	489
88 – Shawnee	20	Observer needed		
89 – Meadowdale	21	Martin Hicks	15	391
90 – Lusk	21	Grant Frost	22	456
91 – Lingle	21	Nathan Darnall	41	840
92 – Diamondville	--	N/A – discontinued		
93 – Mountain View	22	Martin Hicks	Not conducted	Not conducted
94 – no route	--	N/A – discontinued		
95 – Green River	--	N/A – discontinued		
96 – Reliance	23	Observer needed		
97 – Rock Springs	23	Fern Linton	31	266
98 – Black Rock	--	N/A – discontinued		
99 – Kaycee	12	Charlotte Snoberger	23	357
100 – no route	--	N/A – no route		
101 – Wamsutter	25	Tony Mong	Not conducted	Not conducted
102 – Rawlins*	25	Sandra Taylor	16	71
103 – Baggs	25	Tony Mong	Not conducted	Not conducted
104 – Walcott*	26	Frank Blomquist	55	416
105 – Fox Park	26	Wendy Estes-Zumpf	36	413
106 – Ryan Park	26	Debbie Wagner	Not conducted	Not conducted
107 – Sybille Canyon	27	Ian Abernethy	51	1010
108 – Rock River	27	Matt Carling	Not conducted	Not conducted
109 – Harmony*	27	Doug Keinath	49	466
110 – Cheyenne	28	Chuck Seniawski	21	437
111 – Chugwater	28	Chuck Seniawski	26	494
112 – Pine Bluff	28	Chuck Seniawski	19	454
120 – Welch	20	Chris Michelson	32	381
123 – Flaming Gorge	23	Observer needed		
147 – Rozet	6	Observer needed		
148 – Seely 2	7	Mary Yemington	44	491
150 – Government Valley	7	Jennifer Adams	34	496
167 – Thunder Basin	13	Nichole Cudworth	22	418
173 – Rye Grass	15	Theresa Gulbrandson	22	380
180 – Gas Hills 2	18	Courtney Rudd	16	401
192 – Carter	23	Observer needed		
195 – Seedskadee	23	Tom Koerner	63	1,787
198 – Black Rock 2	24	Andrea Orabona	Not conducted	Not conducted
204 – Basin 2	4	Observer needed		
206 – Caballa Creek	6	Sandra Johnson	Not conducted	Not conducted

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
208 – Moran	8	Mikael Cejtin	Not conducted	Not conducted
212 – Bucknum	12	Larry Keffer	Not conducted	Not conducted
214 – Hampshire	14	Nathan Darnall	19	386
224 – Patrick Draw III		N/A – discontinued		
250 – Moskee 2	7	Jennifer Adams	49	502
524 – Patrick Draw VI	24	Laurie Van Fleet	Not conducted	Not conducted
900 – Hayden Valley		N/A – discontinued		
901 – Yellowstone, YNP*	1	John Parker	54	2018
902 – Pryor Flats	1	Observer needed		

Table 2. Number of individuals and relative abundance of each species detected on Breeding Bird Survey routes in Wyoming, 2014. Data are presented in alphabetical order. The 30 most abundant species detected on BBS routes in 2014 are denoted by an asterisk.

Species name	Number detected	Relative abundance (%)
American Three-toed Woodpecker	9	0.03
American Avocet	35	0.11
American Coot	26	0.08
American Crow	127	0.39
American Dipper	2	0.01
American Goldfinch	122	0.37
American Kestrel	89	0.27
American Pipit	1	0.00
American Redstart	38	0.12
American Robin*	1087	3.33
American White Pelican	155	0.47
American Wigeon	25	0.08
Ash-throated Flycatcher	1	0.00
Bald Eagle	25	0.08
Bank Swallow	92	0.28
Barn Swallow*	294	0.90
Barrow’s Goldeneye	15	0.05
Belted Kingfisher	3	0.01
Bewick’s Wren	2	0.01
Black-billed Magpie*	363	1.11
Black-capped Chickadee	37	0.11
Black-headed Grosbeak	35	0.11
Black-throated Gray Warbler	1	0.00
Blue Grosbeak	8	0.02
Blue Jay	14	0.04
Blue-gray Gnatcatcher	1	0.00
Blue-winged Teal	8	0.02
Bobolink	12	0.04
Brewer’s Blackbird*	954	2.92
Brewer’s Sparrow*	1047	3.20
Broad-tailed Hummingbird	30	0.09
Brown Creeper	1	0.00
Brown Thrasher	6	0.02
Brown-headed Cowbird	233	0.71
Bufflehead	7	0.02
Bullock’s Oriole	74	0.23
Burrowing Owl	4	0.01
California Gull	86	0.26

Table 2. Continued.

Species name	Number detected	Relative abundance (%)
Canada Goose*	1597	4.89
Canyon Wren	2	0.01
Caspian Tern	2	0.01
Cassin's Finch	26	0.08
Cassin's Kingbird	1	0.00
Cassin's Sparrow	1	0.00
Cedar Waxwing	6	0.02
Chestnut-collared Longspur	2	0.01
Chipping Sparrow	223	0.68
Chukar	7	0.02
Cinnamon Teal	19	0.06
Clark's Nutcracker	64	0.20
Clay-colored Sparrow	20	0.06
Cliff Swallow*	1457	4.46
Common Grackle*	429	1.31
Common Merganser	56	0.17
Common Nighthawk	159	0.49
Common Poorwill	7	0.02
Common Raven*	276	0.84
Common Yellowthroat	53	0.16
Cooper's Hawk	1	0.00
Cordilleran Flycatcher	12	0.04
Dark-eyed Junco	261	0.80
Dickcissel	10	0.03
Double-crested Cormorant	12	0.04
Downy Woodpecker	5	0.02
Dusky Flycatcher	89	0.27
Dusky Grouse	1	0.00
Eared Grebe	14	0.04
Eastern Kingbird	67	0.21
Eurasian Collared-Dove	125	0.38
European Starling*	747	2.29
Ferruginous Hawk	10	0.03
Field Sparrow	6	0.02
Forster's Tern	1	0.00
Fox Sparrow	10	0.03
Gadwall	15	0.05
Golden Eagle	26	0.08
Golden-crowned Kinglet	2	0.01
Grasshopper Sparrow	93	0.28

Table 2. Continued.

Species name	Number detected	Relative abundance (%)
Gray Catbird	41	0.13
Gray Flycatcher	1	0.00
Gray Jay	8	0.02
Great Blue Heron	24	0.07
Great Egret	2	0.01
Great Horned Owl	4	0.01
Great-tailed Grackle	3	0.01
Greater Sage-Grouse	14	0.04
Green-tailed Towhee*	296	0.91
Green-winged Teal	18	0.06
Hairy Woodpecker	17	0.05
Hammond's Flycatcher	6	0.02
Hermit Thrush	140	0.43
Horned Lark*	1886	5.77
House Finch	20	0.06
House Sparrow	216	0.66
House Wren	155	0.47
Killdeer	184	0.56
Lark Bunting	2727	8.35
Lark Sparrow*	255	0.78
Lazuli Bunting*	71	0.22
Least Flycatcher	7	0.02
Lesser Scaup	32	0.10
Lewis's Woodpecker	1	0.00
Lincoln's Sparrow	94	0.29
Loggerhead Shrike	65	0.20
Long-billed Curlew	32	0.10
MacGillivray's Warbler	32	0.10
Mallard	117	0.36
Marsh Wren	127	0.39
McCown's Longspur	48	0.15
Mountain Bluebird*	280	0.86
Mountain Chickadee	102	0.31
Mountain Plover	4	0.01
Mourning Dove*	1256	3.84
Northern Harrier	21	0.06
Northern Mockingbird	2	0.01
Northern Pintail	6	0.02
Northern Rough-winged Swallow	95	0.29
Northern Shoveler	4	0.01

Table 2. Continued.

Species name	Number detected	Relative abundance (%)
Olive-sided Flycatcher	12	0.04
Orange-crowned Warbler	7	0.02
Orchard Oriole	3	0.01
Osprey	4	0.01
Ovenbird	61	0.19
Pied-billed Grebe	10	0.03
Pine Grosbeak	7	0.02
Pine Siskin	128	0.39
Pinyon Jay	4	0.01
Plumbeous Vireo	7	0.02
Prairie Falcon	6	0.02
Pygmy Nuthatch	3	0.01
Red Crossbill	55	0.17
Red-breasted Nuthatch	46	0.14
Red-eyed Vireo	13	0.04
Red-headed Woodpecker	3	0.01
Red-naped Sapsucker	17	0.05
Red-shafted Flicker	155	0.47
Red-tailed Hawk	84	0.26
Red-winged Blackbird*	1487	4.55
Redhead	16	0.05
Ring-billed Gull	96	0.29
Ring-necked Duck	9	0.03
Ring-necked Pheasant	178	0.54
Rock Pigeon	58	0.18
Rock Wren*	260	0.80
Ruby-crowned Kinglet*	275	0.84
Ruddy Duck	16	0.05
Rufous Hummingbird	1	0.00
Sage Thrasher*	568	1.74
Sagebrush Sparrow	206	0.63
Sandhill Crane	74	0.23
Savannah Sparrow*	259	0.79
Say's Phoebe	57	0.17
Sharp-shinned Hawk	1	0.00
Sharp-tailed Grouse	1	0.00
Short-eared Owl	2	0.01
Song Sparrow*	236	0.72
Sora	7	0.02
Spotted Sandpiper	74	0.23

Table 2. Continued.

Species name	Number detected	Relative abundance (%)
Spotted Towhee	123	0.38
Steller's Jay	1	0.00
Swainson's Hawk	21	0.06
Swainson's Thrush	42	0.13
Townsend's Solitaire	17	0.05
Tree Swallow*	306	0.94
Trumpeter Swan	10	0.03
Turkey Vulture	123	0.38
Unidentified Empidonax flycatcher	3	0.01
Unidentified flicker	19	0.06
Unidentified woodpecker	5	0.02
Unidentified Buteo hawk	2	0.01
Upland Sandpiper	37	0.11
Veery	18	0.06
Vesper Sparrow*	1044	3.20
Violet-green Swallow*	260	0.80
Warbling Vireo*	316	0.97
Western Grebe	11	0.03
Western Kingbird*	234	0.72
Western Meadowlark*	4516	13.82
Western Tanager	100	0.31
Western Wood-Pewee	152	0.47
White-crowned Sparrow	168	0.51
White-breasted Nuthatch	4	0.01
White-throated Swift	30	0.09
Wild Turkey	27	0.08
Willet	12	0.04
Williamson Sapsucker	2	0.01
Willow Flycatcher	28	0.09
Wilson's Phalarope	58	0.18
Wilson's Snipe	141	0.43
Wilson's Warbler	12	0.04
Yellow Warbler*	411	1.26
Yellow-breasted Chat	34	0.10
Yellow-headed Blackbird	175	0.54
Yellow-rumped Warbler*	299	0.92
Total individuals	*32,668*	
Total species	*191*	

Table 3. Population trends (i.e., % change per year) and relative abundance (i.e., individuals per route) of avian Species of Greatest Conservation Need with stable populations in Wyoming that are adequately monitored (i.e., ≥14 survey routes with detections and relative abundance >1 bird per route) by the Breeding Bird Survey, 1966-2013 (analysis by Sauer et al. 2014). The 95% Lower Confidence Limit (LCL) and Upper Confidence Limit (UCL) are also presented for the reported trend. Total number of survey routes used in the analysis for each species is represented by *n*. Results are presented in alphabetical order.

Species	Trend	LCL	UCL	Relative abundance	*n*
Brewer's Sparrow	-0.38	-1.44	0.61	60.87	118
Grasshopper Sparrow	0.87	-1.59	3.24	2.36	66
Sage Thrasher	-0.53	-1.64	0.53	51.13	94

Table 4. Population trends (i.e., % change per year) and relative abundance (i.e., individuals per route) of avian Species of Greatest Conservation Need with increasing populations in Wyoming that are adequately monitored (i.e., ≥14 survey routes with detections and relative abundance >1 bird per route) by the Breeding Bird Survey, 1966-2013 (analysis by Sauer et al. 2014). The 95% Lower Confidence Limit (LCL) and Upper Confidence Limit (UCL) are also presented for the reported trend. Total number of survey routes used in the analysis for each species is represented by *n*. Results are presented in alphabetical order.

Species	Trend	LCL	UCL	Relative abundance	*n*
Greater Sandhill Crane	4.94	2.99	7.16	1.41	54
Sagebrush Sparrow	1.98	0.09	3.96	18.54	73

Table 5. Population trend (i.e., % change per year) and relative abundance (i.e., individuals per route) of avian Species of Greatest Conservation Need with a decreasing population in Wyoming that is adequately monitored (i.e., ≥14 survey routes with detections and relative abundance >1 bird per route) by the Breeding Bird Survey, 1966-2013 (analysis by Sauer et al. 2014). The 95% Lower Confidence Limit (LCL) and Upper Confidence Limit (UCL) are also presented for the reported trend. Total number of survey routes used in the analysis for each species is represented by *n*.

Species	Trend	LCL	UCL	Relative abundance	*n*
Lark Bunting	-2.98	-5.21	-1.32	496.11	108

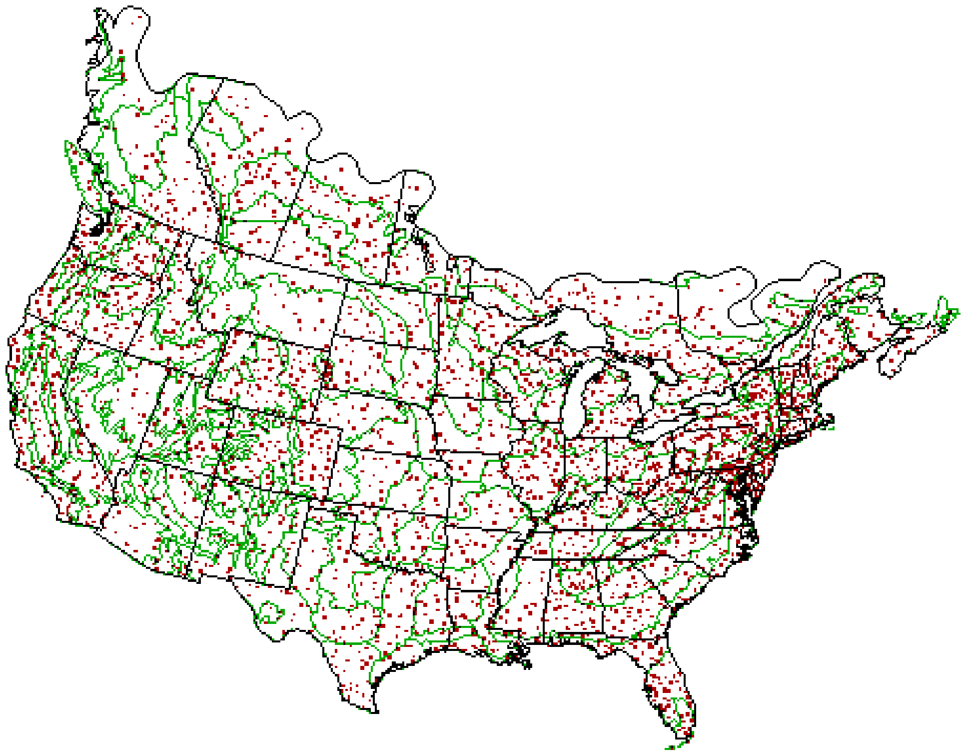

Figure 1. Location (red dots) of all Breeding Bird Survey routes in the United States and Canada (Sauer et al. 1997).

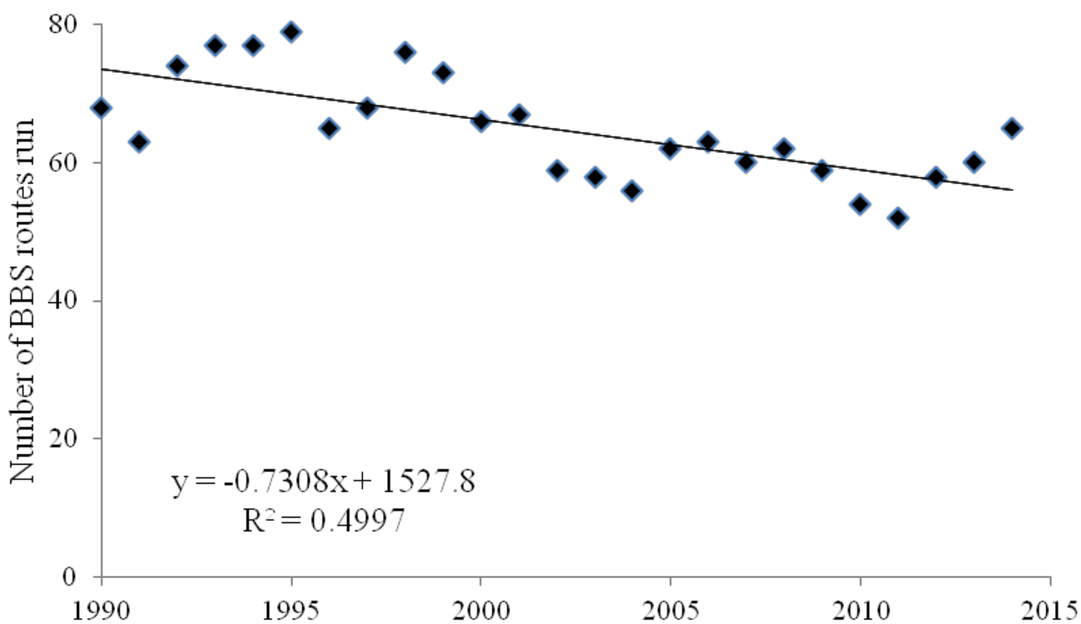

Figure 2. Number of Breeding Bird Survey routes completed in Wyoming, 1990-2014. Only currently active routes with data submitted to the Breeding Bird Survey are included in the analysis. The trend line is shown for reference.

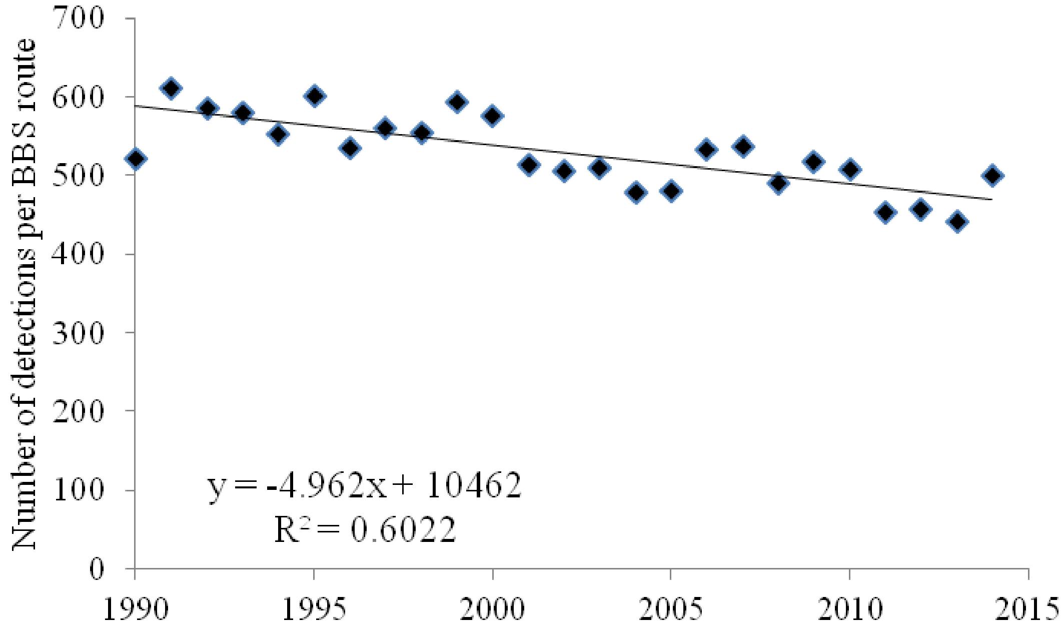

Figure 3. Average number of individual detections of birds per Breeding Bird Survey route in Wyoming, 1990-2014. Only currently active routes with data submitted to the Breeding Bird Survey are included in the analysis. The trend line is shown for reference.

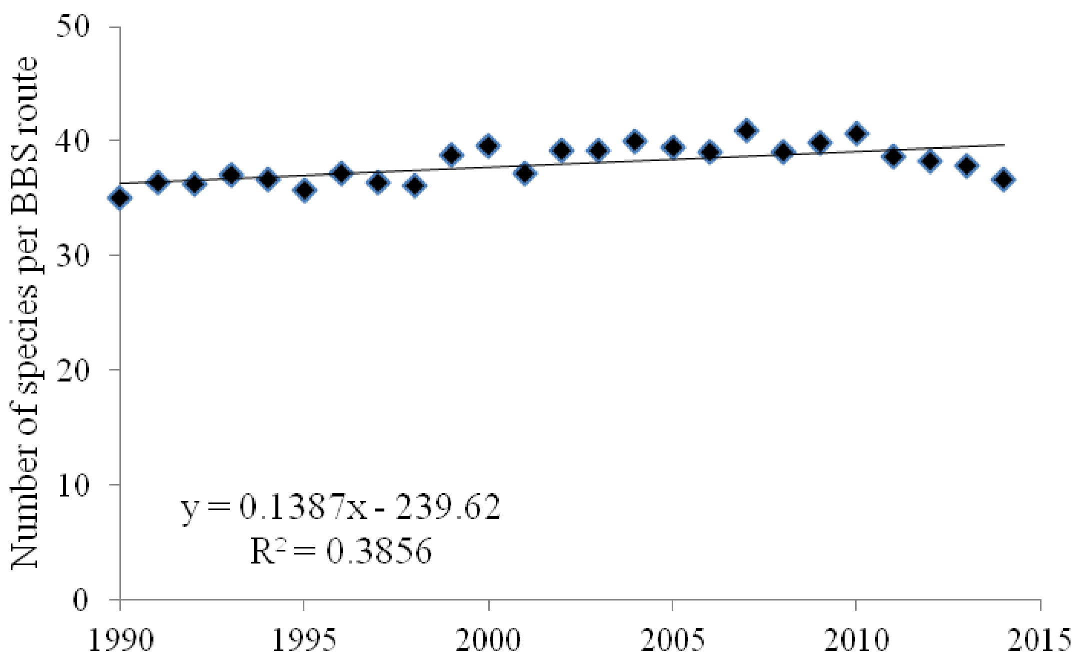

Figure 4. Average number of species detected per Breeding Bird Survey route in Wyoming, 1990-2014. Only currently active routes with data submitted to the Breeding Bird Survey are included in the analysis. The trend line is shown for reference.

WYOMING PARTNERS IN FLIGHT AND INTEGRATED MONITORING IN BIRD CONSERVATION REGIONS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Bureau of Land Management Cooperative Agreement
National Park Service Cooperative Agreement
United States Fish and Wildlife Service State Wildlife Grants
United States Forest Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2015 – 14 April 2016

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ABSTRACT

Landbird populations have declined due to a variety of influences, both natural and human-caused. The Partners in Flight program was initiated in 1990 to address these declines through comprehensive bird conservation planning efforts. Wyoming's working group, Wyoming Partners in Flight, produced the Wyoming Bird Conservation Plan, Version 2.0, which presents avian population objectives, habitat objectives, Best Management Practices to benefit birds, and recommendations to ensure the viability of birds and their habitats, and was used to develop portions of the State Wildlife Action Plan (Nicholoff 2003, WGFD 2010). Monitoring is a key component of the Wyoming Bird Conservation Plan. Through cooperative funding via Wyoming Partners in Flight, numerous partners have jointly implemented the Integrated Monitoring in Bird Conservation Regions program (formerly Monitoring Wyoming's Birds) through the Bird Conservancy of the Rockies (formerly Rocky Mountain Bird Observatory). Data gathered from this program allow us to estimate density, population size, occupancy, and detection probabilities for numerous avian species, including Species of Greatest Conservation

Need (SGCN). In 2015, field technicians completed 2,972 point counts on 241 of the 242 planned survey grids (99.6%) within the 37 strata in the 5 Bird Conservation Regions in Wyoming, covering a total of 253,747 km^2. They detected 216 species, including 34 SGCN. Biometricians estimated occupancy for 158 species (73.1%), including 20 SGCN. Data provided robust estimates for 95 species, (44.0%), including 9 SGCN. Biometricians estimated density and population size for 159 species (73.6%), including 20 SGCN. Data provided robust estimates for 80 species (50.3%), including 7 SGCN. The Integrated Monitoring in Bird Conservation Regions design allows us to monitor trends of avian SGCN that may be overlooked or under-represented by other survey techniques, including sagebrush- and grassland-obligate species; permits slight modifications to the design in order to investigate other priority species as needs arise; reduces monitoring costs through coordination and collaboration with monitoring partners; and can be stepped up to evaluate population parameters on a regional scale.

INTRODUCTION

Long-term data analyses indicate that trends for many populations of North American landbirds have declined due to land use changes; habitat loss, fragmentation, and deterioration; pesticide use; and human influences and disturbance (Robbins et al. 1989, Peterjohn et al. 1995, Sauer et al. 1996, Boren et al. 1999, Donovan and Flather 2002). The International Partners in Flight (PIF) program was initiated in 1990 to address and reverse these declines. The PIF mission is to help species at risk and to keep common birds common through voluntary partnerships that benefit birds, habitats, and people. State, regional, national, and international Bird Conservation Plans comprehensively address the issues of avian and habitat conservation on a landscape scale. The North American Bird Conservation Initiative (NABCI) was initiated in 1998 to ensure the long-term health of North America's native bird populations through effective conservation initiatives, enhanced coordination among the initiatives, and increased cooperation among the governments and citizens of Canada, the US, and Mexico (NABCI 2012).

The state PIF working group, Wyoming Partners in Flight (WYPIF), was established in 1991 and is comprised of participants from the Wyoming Game and Fish Department (Department), Bird Conservancy of the Rockies (Bird Conservancy; formerly Rocky Mountain Bird Observatory), Bureau of Land Management (BLM), US Forest Service (USFS), US Fish and Wildlife Service, Bureau of Reclamation, National Park Service (NPS), Audubon Rockies and affiliate chapters, Wyoming Natural Diversity Database (WYNDD), University of Wyoming, and The Nature Conservancy. The Department's Nongame Bird Biologist has served as the WYPIF chairperson since its inception. As a group, WYPIF produced the Wyoming Bird Conservation Plan, Version 2.0 (Plan; Nicholoff 2003). The Plan presents objectives for populations of birds and major habitat groups in the State, Best Management Practices to benefit birds, and recommendations to ensure that populations of birds and the habitats they require remain intact and viable into the future through proactive and restorative management techniques. Many components of the Plan have been used to develop portions of the Wyoming State Wildlife Action Plan (WGFD 2010).

One of the highest priority objectives throughout the Plan for populations of birds is to implement Monitoring Wyoming's Birds: The Plan for Count-based Monitoring (Leukering et al. 2001). Monitoring of populations is an essential component of effective wildlife management and conservation (Witmer 2005, Marsh and Trenham 2008). Besides improving distribution data, monitoring allows us to evaluate populations of target species and detect changes over time (Thompson et al. 1998, Sauer and Knutson 2008), identify species that are at risk (Dreitz et al. 2006), and evaluate responses of populations to management actions (Lyons et al. 2008, Alexander et al. 2009) and landscape and climate change (Baron et al. 2008, Lindenmayer and Likens 2009).

For the 15th consecutive year, biologists from the Department, Bird Conservancy, BLM, USFS, NPS, WYNDD, and Audubon Rockies have collaborated to execute a state-of-the-art avian monitoring program across Wyoming. Resources are provided by numerous federal agency cooperative agreements, State Wildlife Grants funds, and dollars from the Wyoming State Legislature General Fund Appropriations. This cooperative effort allows us to execute a statewide monitoring program for birds and revise distributions and estimate abundance of numerous avian species, including Species of Greatest Conservation Need (SGCN; WGFD 2010). Funding is also provided to develop educational materials and improve outreach opportunities that focus on birds in Wyoming. The Bird Conservancy is responsible for implementing the monitoring program, which originally focused on 6 habitats in Wyoming (i.e., aspen, grassland, juniper woodland, mid-elevation conifer, montane riparian, and shrub-steppe) under the Monitoring Wyoming's Birds design. Since 2009, this monitoring program, now called Integrated Monitoring in Bird Conservation Regions (IMBCR), incorporates a region-wide approach and uses a stratified, spatially balanced, grid-based design (Hanni et al. 2014). The BLM, USFS, NPS, and Department (through State Wildlife Grants support) contribute funding to the program, and WYNDD assists in program monitoring. Audubon Rockies assists with inventory and monitoring for those species that require techniques other than point-counts (e.g., Monitoring Avian Productivity and Survivorship bird banding stations), producing and distributing educational materials on birds and their habitats, and providing nature-based outreach opportunities for the public. The Department conducts annual monitoring for SGCN that require species-specific survey methods (e.g., Common Loon [*Gavia immer*] American Bittern [*Botaurus lentiginosus*], Burrowing Owl [*Athene cunicularia*], Long-billed Curlew [*Numenius americanus*], Mountain Plover [*Charadrius montanus*], Upland Sandpiper [*Bartramia longicauda*], and raptors), prints and distributes PIF educational materials, and provides point data via the Wildlife Observation System database. With funding and guidance from the IMBCR partnership, Bird Conservancy oversees and implements the program, conducts data analyses, maintains the Rocky Mountain Avian Data Center database, and produces an annual IMBCR report.

The IMBCR partnership's monitoring objectives using the IMBCR design (White et al. 2016) are to:

1. Provide robust density, population, and occupancy estimates that account for incomplete detection and are comparable at different geographic extents.
2. Provide long-term status and trend data for all regularly occurring breeding species throughout the study area.
3. Provide a design framework to spatially integrate existing bird monitoring efforts in the region to provide better information on distribution and abundance of breeding landbirds, especially for high priority species.

4. Provide basic habitat association data for most bird species to address habitat management issues.
5. Maintain a high-quality database that is accessible to all of our collaborators, as well as to the public, over the internet in the form of raw and summarized data.
6. Generate decision support tools that help guide conservation efforts and provide a better measure of conservation success.

METHODS

Bird Conservation Regions (BCRs) provide a spatially consistent framework for the IMBCR program (Figure 1). The IMBCR area of inference includes all or parts of 13 western states (Figure 2). Within the BCR sampling frame, all monitoring partners collaborated to define strata and super-strata based on smaller-scale areas to which we wanted to make inferences (e.g., National Forests, BLM lands, individual states). Within each stratum, the IMBCR design used a spatially balanced sampling algorithm (i.e., generalized random-tessellation stratification) to select sample units (Stevens and Olsen 2004). Bird Conservancy biometricians overlaid BCRs with 1 km^2 sample grids, randomly selected sample grids, and used a 4 x 4 point count array with 16 survey points spaced 250 m apart within each sample grid (Figure 3; Hanni et al. 2014). To estimate the variances of population parameters, a minimum of 2 sampling units within each stratum are required (White et al. 2016).

Prior to surveys, field technicians completed an intensive training program covering protocols, bird and plant identification, and distance estimation. Technicians used distance sampling (Buckland et al. 2001) and IMBCR sampling methods established by the Bird Conservancy (Hanni et al. 2014, 2015) to conduct point counts during the field season. They surveyed grids in the morning from 0.5 hour before sunrise to 1100 hours, and surveyed each count point for 6 minutes to facilitate estimation of site occupancy. For each bird detected, technicians recorded species, sex, horizontal distance from the observer, minute of detection, and type of detection (e.g., song, call, visual). Other data were also noted, such as the presence of migrants, flyovers, clusters, and species difficult to detect, as well as the presence of American pika (*Ochotona princeps*), Abert's squirrels (*Sciurus aberti*), and red squirrels (*Tamiasciurus hudsonicus*). Technicians recorded time, ambient temperature, cloud cover, precipitation, and wind speed at the start and end of each grid survey. They also recorded vegetation data within a 50-m radius of each survey point and included dominant habitat type and relative abundance; species, percent cover, and mean height of trees and shrubs; grass height; and ground cover types. Distance from a road, if within 100 m, was also noted.

Biometricians from the Bird Conservancy used Distance 6.0 to estimate detection probabilities (Buckland et al. 2001, Thomas et al. 2010). They used the SPSURVEY package in Program R to estimate density, population size, and occupancy for species detected in individual strata or combinations of strata at various biologically meaningful spatial scales (White et al. 2016). Lastly, they used a removal design to estimate detection probability for each species (MacKenzie et al. 2006).

RESULTS

In 2015, the IMBCR program encompassed 3 entire states (Colorado, Montana, and Wyoming); portions of 10 additional states (Arizona, Idaho, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Utah); 2 entire USFS Regions (Regions 1 and 2); portions of 2 additional USFS Regions (Regions 3 and 4); all of BCR 17 (Badlands and Prairies); and portions of BCRs 9 (Great Basin), 10 (Northern Rockies), 11 (Prairie Potholes), 16 (Southern Rockies/Colorado Plateau), 18 (Shortgrass Prairie), 19 (Central Mixed-grass Prairie), and 34 (Sierra Madre Occidental; White et al. 2016; Figure 2).

Between 16 May and 24 July 2015, field technicians and biologists with Bird Conservancy and WYNDD completed 2,972 point counts on 241 of the 242 planned survey grids (99.6%) within the 37 strata in the 5 BCRs in Wyoming, covering a total of 253,747 km^2 (White et al. 2016; Table 1; Figures 1 and 4). Statewide results were obtained by compiling and jointly analyzing data from survey locations within the 37 different strata (White et al. 2016).

Field personnel detected a total of 216 species in 2015, including 34 SGCN (White et al. 2016). Bird Conservancy biometricians were able to estimate occupancy, or the proportion of 1 km^2 grid cells occupied, (Psi; ψ) for 158 of the 216 species (73.1%), 20 of which are SGCN (Table 2). Data provided robust estimates (CV <50%) for 95 species (44.0%), including 9 SGCN (Table 2). Bird Conservancy biometricians were able to estimate density (D) and population size (N) for 159 of the 216 species (73.6%), 20 of which are SGCN (Table 3). Data provided robust density estimates (CV <50%) for 80 of the 159 species (50.3%), including 7 SGCN (Table 3).

Annual and multi-year reports, species accounts, and density estimate tables and graphs from the IMBCR program are available on the Rocky Mountain Avian Data Center web site (Bird Conservancy 2016). To view survey locations in Wyoming, occupancy and density results, and species counts across all years of the IMBCR program, follow this link http://www.rmbo.org/new_site/adc/QueryWindow.aspx#N4IgzgrgDgpgTmALnAhoiBbEAuEB1ATRAF8gAA and click the "Run Query" button highlighted in red near the top of the page. To view just the 2015 field season results, follow the link, select "Year" from the Filter drop down box on the top left of the screen, click the "Add" button, select 2015, click "Add Filter", and then click "Run Query" (White et al. 2016).

DISCUSSION

The methods employed by Bird Conservancy of the Rockies and project partners to monitor avian populations using the IMBCR design enable us to estimate occupancy, density, and population size for each species when sample sizes are large enough. These robust data not only allow for continuous monitoring of species trends, but also provide information on species abundance and distribution, habitat associations, and evaluation of land management activities (White et al. 2016). The IMBCR program provides density and occupancy estimates for a number of avian SGCN at risk in Wyoming due to habitat loss or alteration or for which data on population and trends are lacking. Consequently, the IMBCR program provides the Department with an opportunity to monitor trends of avian SGCN that may be overlooked or under-represented by other survey techniques.

Currently, RBMO has completed the Avian Data Center automated analyses, and is working on posting all habitat data under the Monitoring Wyoming's Birds protocol from 2000-2009 to the current IMBCR grid-based design.

As in previous years, the 2015 IMBCR design will provide robust density and occupancy estimates for avian SGCN in Wyoming, which helps fill gaps in current monitoring efforts by the Department. Data collected on all species, including SGCN, help address a number of management challenges, including data deficiencies, habitat loss or degradation, and population declines. Specifically, the IMBCR program provides a quantified approach for monitoring several SGCN. The American Three-toed Woodpecker (*Picoides tridactylus*) is found in higher elevation mature and old-growth coniferous forests, and is classified as a Native Species Status Unknown (NSSU) due to unknown population status and trends resulting from existing monitoring efforts that were insufficient to adequately detect this species (WGFD 2010). Three additional species, Brewer's Sparrow (*Spizella breweri*), Sagebrush Sparrow (*Artemesiospiza nevadensis*), and Sage Thrasher (*Oreoscoptes montanus*), are considered sagebrush obligates, and the Grasshopper Sparrow (*Ammodramus savannarum*), Lark Bunting (*Calamospiza melanocorys*), and McCown's Longspur (*Rhynchophanes mccownii*) are associated with grasslands. Both of these habitats are at high risk for degradation, alteration, or loss, with grasslands listed among the most imperiled habitats in the US and exhibiting dramatic declines in avian populations (WYPIF 2002, WGFD 2010). Consequently, by monitoring SGCN, the IMBCR program can provide an indication of trends for these species, as well as a suite of sagebrush and grassland associated species. However, several SGCN, including the Lewis's Woodpecker (*Melanerpes lewis*), Willow Flycatcher (*Empidonax traillii*), Chestnut-collared Longspur (*Calcarius ornatus*) Bobolink (*Dolichonys oryzivorus*), and Dickcissel (*Spiza americana*), have not been detected in sufficient numbers to estimate occupancy or density. If this trend continues, we will need to implement a more targeted approach for these species to obtain adequate population information.

The IMBCR design and hierarchical framework of nested strata provide accurate information about bird populations on multiple scales, from local management units to BCRs. Population estimates at the management unit scale can be used to support local management efforts, while regional- and BCR-level monitoring provides managers with dependable information about the status and changes of bird populations at ecologically relevant scales (NABCI 2009). Managers can also compare population estimates at the management unit scale to those at the BCR scale to provide a regional context for the estimates, allowing for informed conservation planning and an accurate assessment of conservation responsibility (White et al. 2016).

There are 5 major categories for management applications from IMBCR data (White et al. 2015):

1. The ability to compare estimates of bird populations in space and time. For example, estimates at the state and regional levels can be compared with stratum-level estimates to determine whether local populations are above or below estimates for the region.

2. Population estimates can help inform management decisions about where to focus conservation efforts. For example, managers can focus protection strategies on strata with large populations of avian species, and conservation actions can be targeted to those strata with lower populations. Managers could set thresholds that trigger specific management actions when populations reach preset levels.
3. The effectiveness of management actions within treatment areas can be evaluated by comparing stratum-level population estimates of those treatment areas to regional estimates. For example, population estimates within manipulated areas can be compared to regional estimates to determine if the treatment is beneficial or detrimental to the avian species present.
4. Annual density and occupancy estimates can be compared over time to determine if population changes are a result of population growth or decline and/or range expansion or contraction. For example, if occupancy rates of a particular species remains constant but population density declined over time, then declines in local abundance was the cause of the population change. Moreover, if both density and occupancy rates of a species declined, then range contraction was the cause of the change in population.
5. The area of land occupied by a particular species can be estimated by multiplying the size of the land area by the species' occupancy rate. For example, if the land area comprises 120,000 km^2 and the occupancy rate for a particular species is 0.57, managers can estimate that 68,400 km^2 of habitat within that land area are occupied by that species.

The IMBCR's spatially balanced sampling design is more efficient than simple random sampling and can increase precision in density, occupancy, and detection probability estimates (Stevens and Olsen 2004, White et al. 2016). Additionally, this sampling design provides the flexibility to generate population estimates at various scales relevant to land and wildlife management agencies, enabling managers to use population estimates to make informed management decisions about where to focus conservation efforts. It also allows sampling of all habitats, which enables managers to relate changes in bird populations to changes on the landscape over time. These results support both local and regional conservation efforts in Wyoming. The IMBCR design can also be used in research applications as overlay or auxiliary projects, which incorporate detection data from the IMBCR program into the research project's analyses. Moreover, the IMBCR design allows us to monitor trends of avian SGCN that may be omitted or inadequately represented by other survey techniques, permits slight modifications to the design in order to investigate other priority species as needs arise, and reduces monitoring costs through coordination and collaboration with monitoring partners.

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LITERATURE CITED

Alexander, J. D., J. L. Stevens, G. R. Geupel, and T. C. Will. 2009. Decision support tools: bridging the gap between science and management. Pages 283-291 *in* Tundra to tropics: connecting birds, habitats and people. Proceedings of the 4th International Partners in Flight Conference, 13-16 February 2008 (T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson, Editors). Partners in Flight, McAllen, Texas, USA.

Baron, J. S., S. H. Julius, J. M. West, L. A. Joyce, G. Blate, C. H. Peterson, M. Palmer, B. D. Keller, P. Kareiva, J. M. Scott, and B. Griffith. 2008. Some guidelines for helping natural resources adapt to climate change. International Human Dimensions Programme on Global Environmental Change Update 2:46-52.

Bird Conservancy of the Rockies [Bird Conservancy]. 2016. The Rocky Mountain Bird Observatory Avian Data Center, Brighton, Colorado, USA. http://rmbo.org/v3/avian/Home.aspx (accessed 3 June 2016).

Boren, J. C., D. M. Engle, M. W. Palmer, R. E. Masters, and T. Criner. 1999. Land use change effects on breeding bird community composition. Journal of Range Management 52:420-430.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, United Kingdom.

Donovan, T. M., and C. H. Flather. 2002. Relationships among North American songbird trends, habitat fragmentation, and landscape occupancy. Ecological Applications 12:364-374.

Dreitz, V. J., P. M. Lukacs, and F. L. Knopf. 2006. Monitoring low density avian populations: an example using Mountain Plovers. Condor 108:700-706.

Hanni, D. J., C. M. White, N. J. Van Lanen, J. J. Birek, J. M. Berven, and M. A. McLaren. 2014. Integrated Monitoring in Bird Conservation Regions (IMBCR): field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA. rmbo.org/v3/avian/DataCollection.aspx (accessed 3 June 2016).

Hanni, D. J., C. M. White, J. J. Birek, N. J. Van Lanen, and M. F. McLaren. 2015. Field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Leukering, T., M. F. Carter, A. Panjabi, D. Faulkner, and R. Levad. 2001. Monitoring Wyoming's birds: the plan for count-based monitoring. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Lindenmayer, D. B., and G. E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution 24:482-486.

Lyons, J. E., M. C. Runge, H. P. Laskowski, and W. L. Kendall. 2008. Monitoring in the context of structured decision-making and adaptive management. Journal of Wildlife Management 72:1683-1692.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier, Burlington, Massachusetts, USA.

Marsh, D. M., and P. C. Trenham. 2008. Current trends in plant and animal population monitoring. Conservation Biology 22:647-655.

Nicholoff, S. H., compiler. 2003. Wyoming bird conservation plan. Version 2.0. Wyoming Partners In Flight. Wyoming Game and Fish Department, Lander, USA.

North American Bird Conservation Initiative [NABCI]. 1999. Bird conservation regions. www.nabci-us.org/map.html (accessed 3 June 2016).

North American Bird Conservation Initiative [NABCI]. 2009. The state of the birds, United States of America, 2009. U.S. Department of Interior, Washington, D.C., USA.

North American Bird Conservation Initiative [NABCI]. 2012. North American Bird Conservation Initiative, USA. www.nabci-us.org/aboutnabci/Charter-only.pdf (accessed 3 June 2016).

Peterjohn, B. G., J. R. Sauer, and C. S. Robbins. 1995. Population trends from the North American Breeding Bird Survey. Pages 3-39 *in* Ecology and management of Neotropical migratory birds (T. E. Martin and D. M. Finch, Editors). Oxford University Press, New York, New York, USA.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy Sciences 86:7658-7662.

Sauer, J. R., G. W. Pendleton, and B. G. Peterjohn. 1996. Evaluating causes of population change in North American insectivorous birds. Conservation Biology 10:465-478.

Sauer, J. R., and M. G. Knutson. 2008. Objectives and metrics for wildlife monitoring. Journal of Wildlife Management 72:1663-1664.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5-14.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California, USA.

White, C. M., M. F. McLaren, N. J. Van Lanen, D. C. Pavlacky Jr., J. A. Blakesley, R. A. Sparks, J. J. Birek, and B. J. Woiderski. 2016. Integrated Monitoring in Bird Conservation Regions (IMBCR): 2015 Field Season Report. Bird Conservancy of the Rockies, Brighton, Colorado, USA.

Witmer, G. W. 2005. Wildlife population monitoring: some practical considerations. Wildlife Research 32:259-263.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Wyoming Partners in Flight [WYPIF]. 2002. Growing grassland birds: best management practices for grasslands to benefit birds in Wyoming. Wyoming Game and Fish Department, Lander, USA.

Table 1. Planned and completed surveys, by stratum, conducted in Wyoming between 16 May and 24 July 2015 using the Integrated Monitoring in Bird Conservation Regions design.

BCR name	BCR number	Number of strata	Strata area (km^2)	Number of surveys planned	Number of surveys completed	Percent surveys completed (%)
Great Basin	9	1	119	2	2	100
Northern Rockies	10	23	165,332	127	127	100
Southern Rockies/Colorado Plateau	16	4	11,594	37	37	100
Badlands and Prairies	17	6	64,444	82	81	98.8
Shortgrass Prairie	18	3	12,258	14	14	100
Statewide total		37	253,747	262	261	99.8

Table 2. Estimated proportion of sample units occupied (ψ), standard error (SE), percent coefficient of variation (% CV), and number of grids with ≥1 detections (*n*) of 21 avian Species of Greatest Conservation Need on Integrated Monitoring in Bird Conservation Regions survey grids throughout Wyoming from 2010-2015. Occupancy estimates are considered robust if % CV <50%, and are noted in bold. Scientific names are presented below the table.

Species common name	Year	Psi (ψ)	SE	% CV	*n*
American Three-toed Woodpecker	**2010**	**0.034**	**0.012**	**34**	**12**
American Three-toed Woodpecker	**2011**	**0.067**	**0.006**	**9**	**15**
American Three-toed Woodpecker	2012	0.025	0.013	52	8
American Three-toed Woodpecker	2013	0.047	0.03	63	8
American Three-toed Woodpecker	**2014**	**0.051**	**0.018**	**35**	**16**
American Three-toed Woodpecker	**2015**	**0.052**	**0.013**	**24**	**16**
Ash-throated Flycatcher	2010	0	0	71	1
Ash-throated Flycatcher	2015	0.022	0.021	96	1
Black Rosy-Finch	2010	0	0	0	5
Black Rosy-Finch	2012	0.028	0.015	55	3
Black Rosy-Finch	2013	0.036	0.02	57	5
Brewer's Sparrow	**2010**	**0.541**	**0.051**	**9**	**80**
Brewer's Sparrow	**2011**	**0.505**	**0.052**	**10**	**77**
Brewer's Sparrow	**2012**	**0.533**	**0.049**	**9**	**87**
Brewer's Sparrow	**2013**	**0.602**	**0.048**	**8**	**97**
Brewer's Sparrow	**2014**	**0.554**	**0.056**	**10**	**83**
Brewer's Sparrow	**2015**	**0.586**	**0.039**	**7**	**121**
Burrowing Owl	2015	0	0	72	1
Chestnut-collared Longspur	2010	0.033	0.021	64	3
Chestnut-collared Longspur	2012	0.023	0.02	88	2
Chestnut-collared Longspur	2013	0.025	0.02	82	3
Chestnut-collared Longspur	2014	0	0	71	1
Chestnut-collared Longspur	2015	0.014	0.01	70	2
Dickcissel	2014	0.006	0.006	94	1
Grasshopper Sparrow	**2010**	**0.128**	**0.036**	**28**	**27**
Grasshopper Sparrow	**2011**	**0.103**	**0.028**	**27**	**26**
Grasshopper Sparrow	**2012**	**0.107**	**0.03**	**28**	**16**
Grasshopper Sparrow	**2013**	**0.062**	**0.029**	**47**	**13**
Grasshopper Sparrow	**2014**	**0.085**	**0.028**	**33**	**15**
Grasshopper Sparrow	**2015**	**0.151**	**0.024**	**16**	**33**
Greater Sage-Grouse	2014	0.033	0	0	1
Lark Bunting	**2010**	**0.199**	**0.037**	**18**	**37**
Lark Bunting	**2011**	**0.144**	**0.029**	**20**	**37**
Lark Bunting	**2012**	**0.17**	**0.038**	**22**	**24**
Lark Bunting	**2013**	**0.196**	**0.042**	**22**	**34**

Table 2. Continued.

Species common name	Year	Psi *(ψ)*	SE	% CV	*n*
Lark Bunting	**2014**	**0.246**	**0.042**	**17**	**34**
Lark Bunting	**2015**	**0.313**	**0.042**	**13**	**56**
Lewis's Woodpecker	2011	0.003	0.003	90	1
Lewis's Woodpecker	2014	0.002	0.002	105	1
Lewis's Woodpecker	2015	0.003	0.003	91	1
Long-billed Curlew	2015	0.01	0.009	98	1
McCown's Longspur	2010	0.045	0.023	52	5
McCown's Longspur	**2011**	**0.022**	**0.01**	**47**	**4**
McCown's Longspur	2012	0.045	0.023	50	6
McCown's Longspur	**2013**	**0.024**	**0.01**	**43**	**4**
McCown's Longspur	2014	0.019	0.01	54	3
McCown's Longspur	**2015**	**0.033**	**0.014**	**43**	**9**
Mountain Plover	2010	0	0	71	1
Mountain Plover	2013	0.003	0.002	62	2
Mountain Plover	2015	0.001	0.001	66	2
Northern Goshawk	2012	0.031	0.027	87	3
Northern Pygmy-Owl	2013	0.001	0.001	110	1
Pygmy Nuthatch	2010	0.001	0.001	59	2
Pygmy Nuthatch	2011	0.008	0.004	58	2
Pygmy Nuthatch	**2012**	**0.004**	**0.002**	**44**	**4**
Pygmy Nuthatch	2013	0.002	0.001	68	2
Pygmy Nuthatch	**2014**	**0.005**	**0.002**	**46**	**4**
Pygmy Nuthatch	2015	0.018	0.017	95	2
Sagebrush Sparrow	**2010**	**0.191**	**0.038**	**20**	**24**
Sagebrush Sparrow	**2011**	**0.161**	**0.029**	**18**	**23**
Sagebrush Sparrow	**2012**	**0.152**	**0.033**	**22**	**22**
Sagebrush Sparrow	**2013**	**0.144**	**0.032**	**22**	**20**
Sagebrush Sparrow	**2014**	**0.123**	**0.031**	**25**	**14**
Sagebrush Sparrow	**2015**	**0.144**	**0.026**	**18**	**23**
Sage Thrasher	**2010**	**0.252**	**0.047**	**18**	**34**
Sage Thrasher	**2011**	**0.238**	**0.039**	**16**	**33**
Sage Thrasher	**2012**	**0.353**	**0.08**	**23**	**38**
Sage Thrasher	**2013**	**0.182**	**0.039**	**21**	**26**
Sage Thrasher	**2014**	**0.223**	**0.048**	**21**	**22**
Sage Thrasher	**2015**	**0.292**	**0.041**	**14**	**46**
Sandhill Crane	2013	0.04	0.038	96	2
Sandhill Crane	2015	0.022	0.02	89	3
Short-eared Owl	2015	0.026	0.017	65	5

Table 2. Continued.

Species common name	Year	Psi (*ψ*)	SE	% CV	*n*
Swainson's Hawk	2010	0.017	0.017	101	2
Swainson's Hawk	2012	0.003	0.003	98	2
Swainson's Hawk	2013	0.141	0.126	89	2
Swainson's Hawk	2014	0.071	0.071	101	1
Swainson's Hawk	2015	0.109	0.076	70	3
Upland Sandpiper	2010	0.038	0.029	77	5
Upland Sandpiper	2011	0.024	0.02	83	6
Upland Sandpiper	2012	0.014	0.008	62	2
Upland Sandpiper	2014	0.076	0.044	58	4
Upland Sandpiper	**2015**	**0.049**	**0.02**	**41**	**8**
Western Scrub-Jay	2015	0.009	0.009	98	1
Willow Flycatcher	2010	0.06	0.04	67	4
Willow Flycatcher	2012	0.059	0.058	98	2
Willow Flycatcher	2013	0.001	0.001	97	1
Willow Flycatcher	2014	0.063	0.058	93	2
Willow Flycatcher	2015	0.024	0.021	88	3

Index of Scientific Names:

American Three-toed Woodpecker	*Picoides dorsalis*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Black Rosy-Finch	*Leucosticte atrata*
Brewer's Sparrow	*Spizella breweri*
Burrowing Owl	*Athene cunicularia*
Chestnut-collared Longspur	*Calcarius ornatus*
Dickcissel	*Spiza americana*
Grasshopper Sparrow	*Ammodramus savannarum*
Greater Sage-Grouse	*Centrocercus urophasianus*
Lark Bunting	*Calamospiza melanocorys*
Lewis's Woodpecker	*Melanerpes lewis*
Long-billed Curlew	*Numenius americanus*
McCown's Longspur	*Rhynchophanes mccownii*
Mountain Plover	*Charadrius montanus*
Northern Goshawk	*Accipiter gentilis*
Northern Pygmy-Owl	*Glaucidium gnoma*
Pygmy Nuthatch	*Sitta pygmaea*
Sagebrush Sparrow	*Artemesiospiza nevadensis*
Sage Thrasher	*Oreoscoptes montanus*
Sandhill Crane	*Grus canadensis*
Short-eared Owl	*Asio flammeus*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*

Western Scrub-Jay	*Aphelocoma californica*
Willow Flycatcher	*Empidonax traillii*

Table 3. Estimated density (*D*; individuals per km^2), population size (*N*), percent coefficient of variation (% CV), and number of independent detections (*n*) of 20 avian Species of Greatest Conservation Need on Integrated Monitoring in Bird Conservation Regions survey grids throughout Wyoming from 2009-2015. Density estimates are considered robust if % CV <50%, and are denoted in bold. Scientific names are presented below the table.

Species common name	Year	D	*N*	% CV	*n*
American Three-toed Woodpecker	**2009**	**0.26**	**48,436**	**33**	**12**
American Three-toed Woodpecker	**2010**	**0.41**	**101,950**	**36**	**25**
American Three-toed Woodpecker	**2011**	**0.28**	**71,550**	**29**	**24**
American Three-toed Woodpecker	2012	0.41	103,059	102	10
American Three-toed Woodpecker	2013	0.62	157,450	78	7
American Three-toed Woodpecker	**2014**	**0.41**	**103,291**	**45**	**24**
American Three-toed Woodpecker	**2015**	**0.32**	**80,214**	**43**	**30**
Ash-throated Flycatcher	2012	0	0	0	0
Ash-throated Flycatcher	2013	0	0	0	0
Ash-throated Flycatcher	2014	0	0	0	0
Ash-throated Flycatcher	2015	0.04	10,838	97	2
Brewer's Sparrow	**2009**	**44.26**	**8,328,561**	**24**	**828**
Brewer's Sparrow	**2010**	**29.75**	**7,481,986**	**13**	**804**
Brewer's Sparrow	**2011**	**30.69**	**7,707,408**	**15**	**824**
Brewer's Sparrow	**2012**	**22.57**	**5,670,208**	**15**	**873**
Brewer's Sparrow	**2013**	**24.2**	**6,134,460**	**16**	**1,235**
Brewer's Sparrow	**2014**	**31.76**	**8,048,826**	**19**	**907**
Brewer's Sparrow	**2015**	**44.27**	**11,220,044**	**12**	**1,875**
Burrowing Owl	2013	0	0	0	0
Burrowing Owl	2014	0	240	99	1
Burrowing Owl	2015	0	64	89	2
Chestnut-collared Longspur	2010	0.44	109,983	54	6
Chestnut-collared Longspur	2012	1.2	302,303	106	9
Chestnut-collared Longspur	2013	0.14	35,401	102	4
Chestnut-collared Longspur	2014	0	380	137	8
Chestnut-collared Longspur	2015	1.1	278,706	97	29
Dickcissel	2012	0	0	0	0
Dickcissel	2013	0	0	0	0
Dickcissel	2014	0.01	3,420	107	1
Dickcissel	2015	0	0	0	0

Table 3. Continued.

Species common name	Year	Psi (*ψ*)	SE	% CV	*n*
Grasshopper Sparrow	**2009**	**2**	**376,107**	**37**	**45**
Grasshopper Sparrow	**2010**	**3.35**	**843,508**	**31**	**98**
Grasshopper Sparrow	**2011**	**3.96**	**994,665**	**24**	**185**
Grasshopper Sparrow	**2012**	**2.82**	**708,620**	**32**	**103**
Grasshopper Sparrow	2013	1.01	256,991	51	52
Grasshopper Sparrow	**2014**	**1.65**	**418,926**	**42**	**66**
Grasshopper Sparrow	**2015**	**5.32**	**1,348,656**	**26**	**178**
Lark Bunting	**2009**	**17.71**	**3,331,982**	**32**	**937**
Lark Bunting	**2010**	**16.85**	**4,236,699**	**26**	**814**
Lark Bunting	**2011**	**14.14**	**3,550,626**	**28**	**814**
Lark Bunting	**2012**	**7.64**	**1,920,207**	**29**	**436**
Lark Bunting	**2013**	**10.46**	**2,650,654**	**30**	**938**
Lark Bunting	**2014**	**13.69**	**3,469,547**	**30**	**1,025**
Lark Bunting	**2015**	**14.57**	**3,692,332**	**17**	**1,098**
Lewis's Woodpecker	2013	0	0	0	0
Lewis's Woodpecker	2014	0	473	101	1
Lewis's Woodpecker	2015	0	0	0	0
Long-billed Curlew	2011	0.16	41,209	86	3
Long-billed Curlew	2012	0.14	34,494	108	3
Long-billed Curlew	2013	0	0	0	0
Long-billed Curlew	2014	0	0	0	0
Long-billed Curlew	2015	0.24	61,444	81	7
McCown's Longspur	2009	2.69	505,993	60	26
McCown's Longspur	2010	1.7	427,797	50	34
McCown's Longspur	2011	1.65	414,502	68	50
McCown's Longspur	2012	2.41	604,745	60	117
McCown's Longspur	2013	2.2	558,239	65	105
McCown's Longspur	2014	0.4	100,987	101	16
McCown's Longspur	2015	4.06	1,028,926	54	112
Mountain Plover	2013	0	863	80	3
Mountain Plover	2014	0.14	34,447	89	17
Mountain Plover	2015	0	381	102	3
Pygmy Nuthatch	2009	0.06	11,493	61	4
Pygmy Nuthatch	2010	0.03	6,868	81	2
Pygmy Nuthatch	2011	0.08	19,321	77	2
Pygmy Nuthatch	2012	0.08	18,969	81	8
Pygmy Nuthatch	2013	0.01	1,980	72	2
Pygmy Nuthatch	2014	0.04	9,243	61	5

Table 3. Continued.

Species common name	Year	Psi (*ψ*)	SE	% CV	*n*
Pygmy Nuthatch	2015	0.06	14,766	72	5
Sagebrush Sparrow	**2009**	**5.57**	**1,047,864**	**18**	**281**
Sagebrush Sparrow	**2010**	**5.01**	**1,260,838**	**23**	**252**
Sagebrush Sparrow	**2011**	**5.79**	**1,453,124**	**21**	**271**
Sagebrush Sparrow	**2012**	**4.25**	**1,067,892**	**30**	**254**
Sagebrush Sparrow	**2013**	**2.49**	**631,410**	**27**	**320**
Sagebrush Sparrow	**2014**	**3.02**	**764,327**	**25**	**234**
Sagebrush Sparrow	**2015**	**6.08**	**1,541,390**	**32**	**507**
Sage Thrasher	**2009**	**2.78**	**522,260**	**16**	**231**
Sage Thrasher	**2010**	**2.63**	**661,911**	**18**	**284**
Sage Thrasher	**2011**	**2.31**	**581,212**	**13**	**405**
Sage Thrasher	**2012**	**2.37**	**594,478**	**17**	**252**
Sage Thrasher	**2013**	**1.22**	**310,125**	**23**	**411**
Sage Thrasher	**2014**	**1.76**	**444,993**	**14**	**278**
Sage Thrasher	**2015**	**3.07**	**778,800**	**18**	**485**
Swainson's Hawk	2009	0.09	16,237	57	9
Swainson's Hawk	2010	0.01	3,587	77	4
Swainson's Hawk	2011	0.02	4,496	71	3
Swainson's Hawk	2012	0	794	80	3
Swainson's Hawk	2013	0.03	8,687	70	3
Swainson's Hawk	2014	0.05	12,241	91	4
Swainson's Hawk	2015	0.07	17,890	77	6
Upland Sandpiper	2010	0.15	38,587	71	12
Upland Sandpiper	2011	0.12	30,357	54	22
Upland Sandpiper	2012	0.02	4,554	70	3
Upland Sandpiper	2013	0.06	14,010	87	8
Upland Sandpiper	2014	0.15	37,022	68	19
Upland Sandpiper	**2015**	**0.16**	**40,730**	**42**	**36**
Western Scrub-Jay	2012	0	0	0	0
Western Scrub-Jay	2013	0	0	0	0
Western Scrub-Jay	2014	0	0	0	0
Western Scrub-Jay	2015	0.02	4,988	101	1
Willow Flycatcher	2013	0.01	2,429	107	1
Willow Flycatcher	2014	0.21	52,528	95	3
Willow Flycatcher	2015	0.44	111,217	96	6

Index of Scientific Names:

American Three-toed Woodpecker	*Picoides dorsalis*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Brewer’s Sparrow	*Spizella breweri*
Burrowing Owl	*Athene cunicularia*
Chestnut-collared Longspur	*Calcarius ornatus*
Dickcissel	*Spiza americana*
Grasshopper Sparrow	*Ammodramus savannarum*
Lark Bunting	*Calamospiza melanocorys*
Lewis’s Woodpecker	*Melanerpes lewis*
Long-billed Curlew	*Numenius americanus*
McCown’s Longspur	*Rhynchophanes mccownii*
Mountain Plover	*Charadrius montanus*
Pygmy Nuthatch	*Sitta pygmaea*
Sagebrush Sparrow	*Artemesiospiza nevadensis*
Sage Thrasher	*Oreoscoptes montanus*
Swainson’s Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Western Scrub-Jay	*Aphelocoma californica*
Willow Flycatcher	*Empidonax traillii*

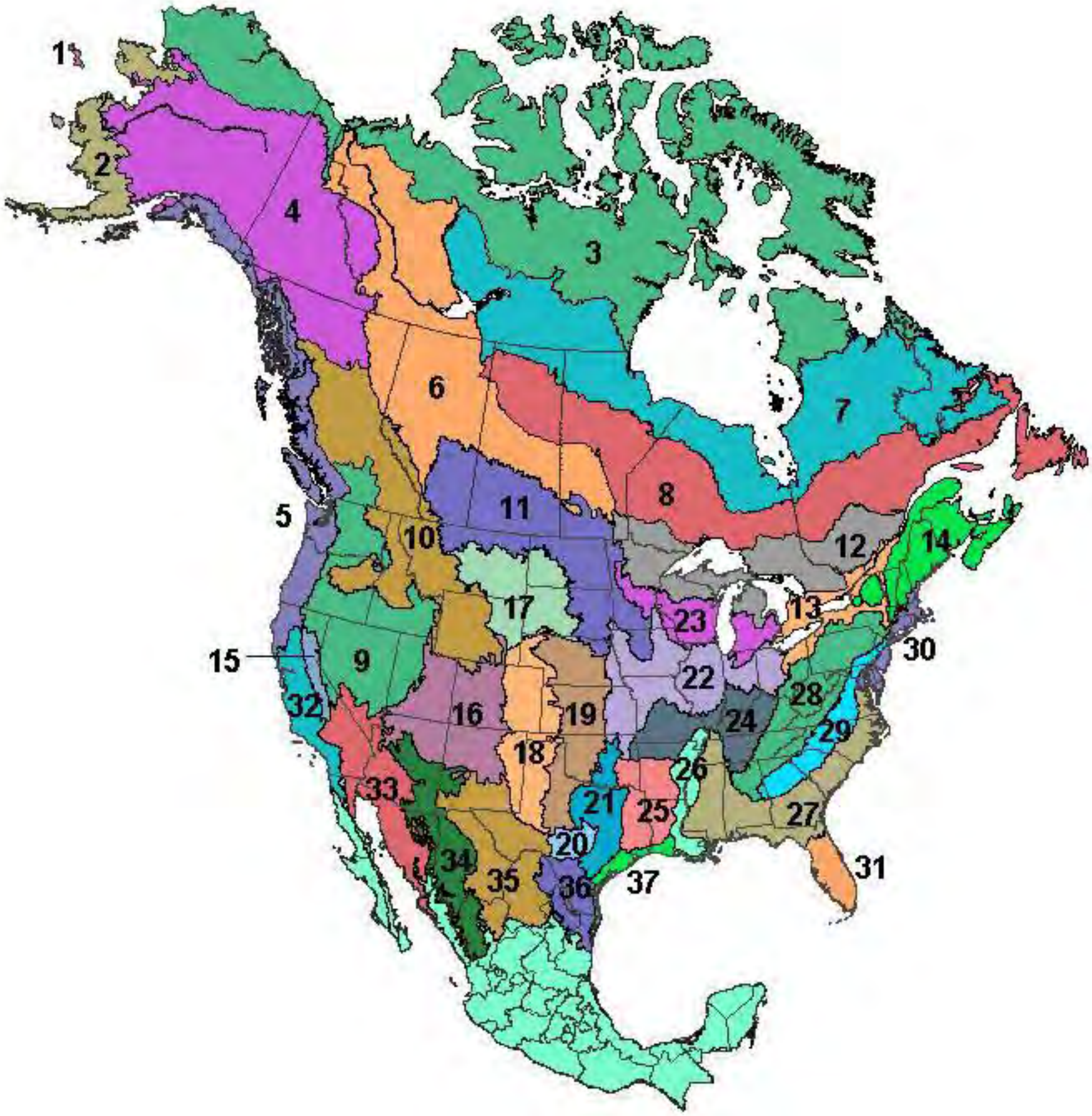

Figure 1. The North American Bird Conservation Region (BCR) map, excluding Hawaii and Mexico (NABCI 1999). Portions of BCRs that occur in Wyoming are: 9 – Great Basin, 10 – Northern Rockies, 16 – Southern Rockies/Colorado Plateau, 17 – Badlands and Prairies, and 18 – Shortgrass Prairie. Surveys were conducted in all BCRs in Wyoming in 2015.

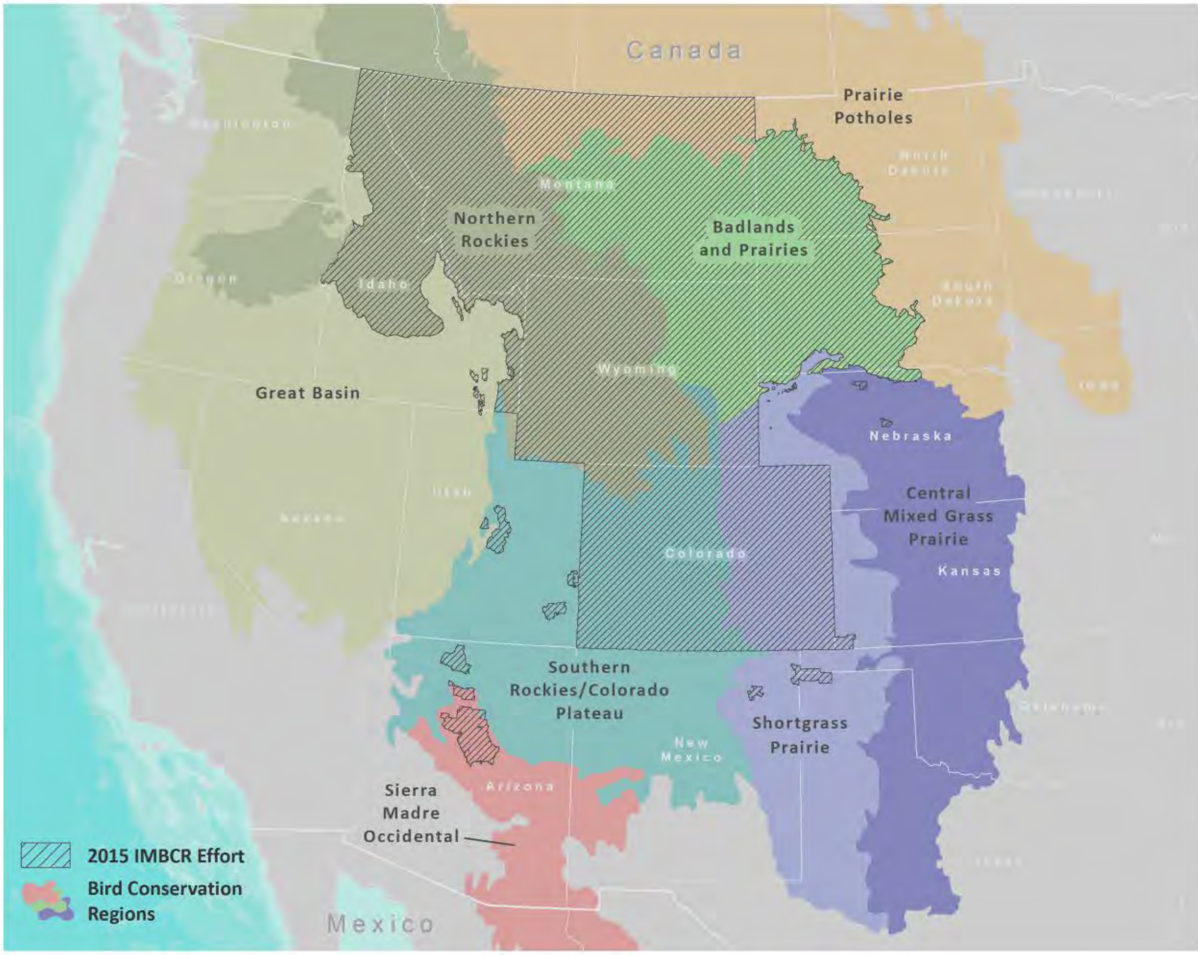

Figure 2. Spatial extent (hashed areas) of the IMBCR program in 2015 (White et al. 2016).

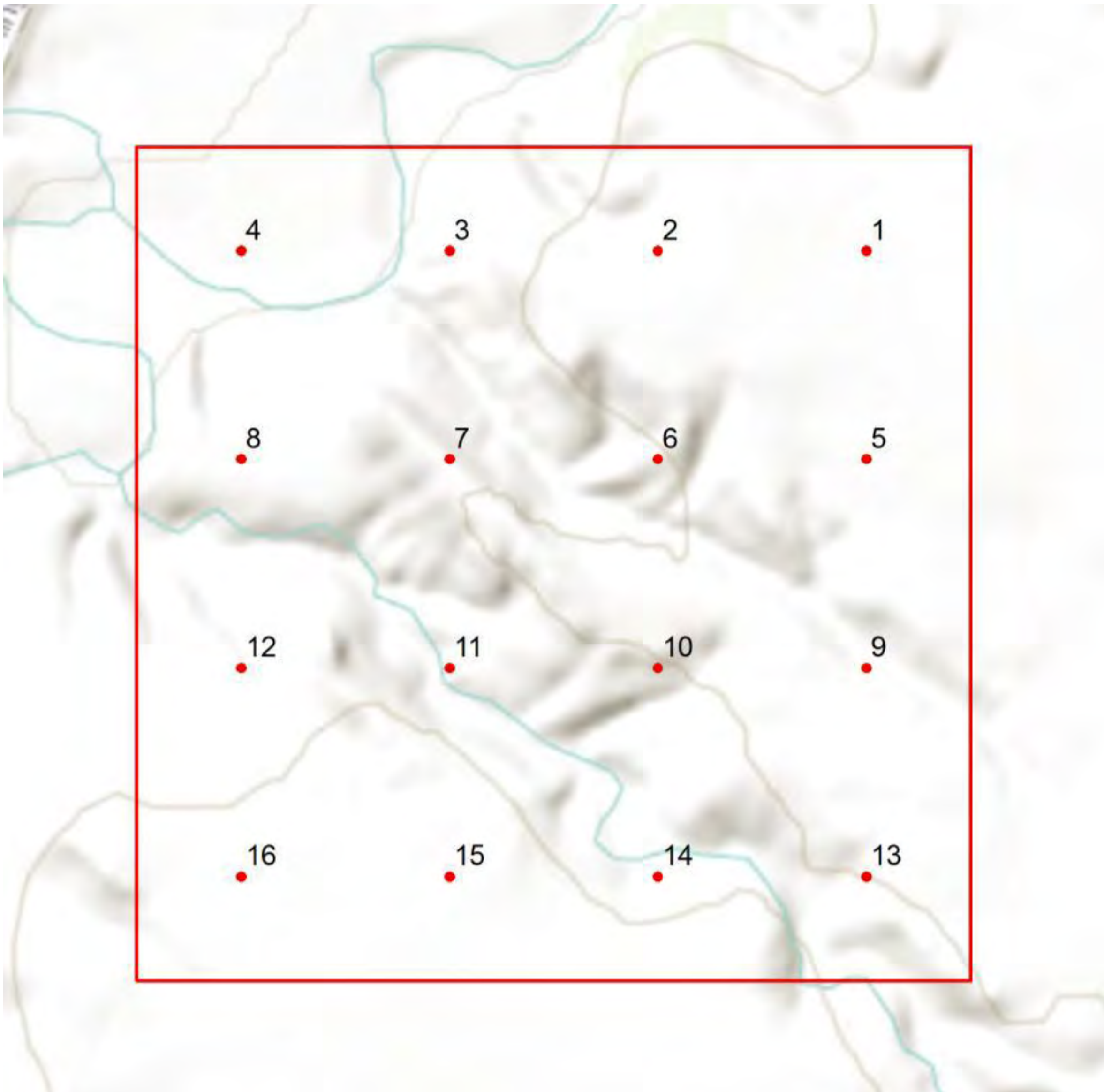

Figure 3. Example of the 1 km^2 sampling unit using the IMBCR design (White et al. 2016).

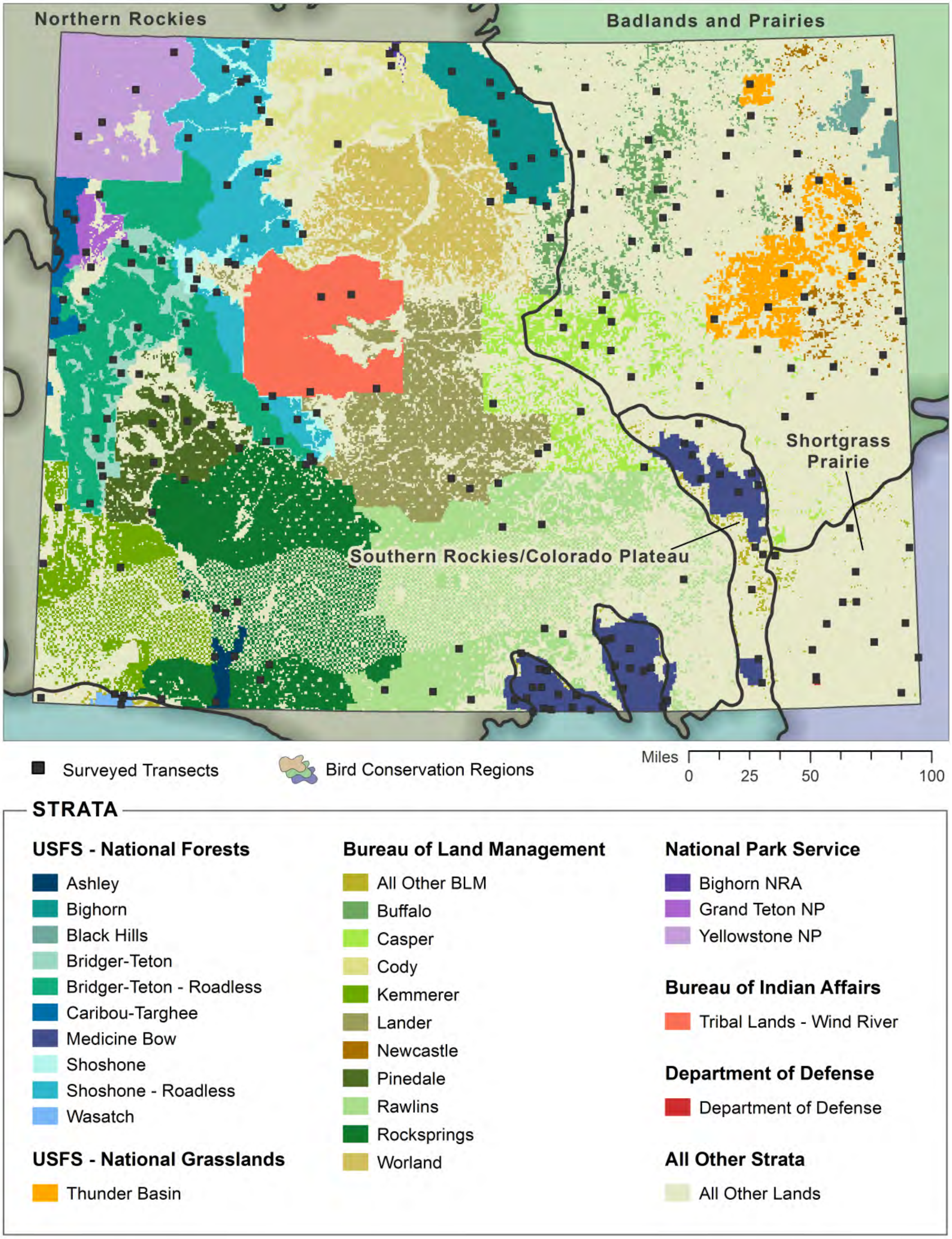

Figure 4. Integrated Monitoring in Bird Conservation Regions strata and survey grid locations in Wyoming, 2015 (White et al. 2016).

OTHER NONGAME – MAMMALS

COORDINATED RANGE-WIDE OCCUPANCY SURVEYS FOR WHITE-TAILED PRAIRIE DOG (*CYNOMYS LEUCURUS*)

STATE OF WYOMING

NONGAME MAMMALS: White-tailed prairie dog

FUNDING SOURCE: United States Fish and Wildlife Service Cooperative Agreement
Wyoming State Legislature General Fund Appropriations
United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: 1 July 2015 – 30 June 2017

PERIOD COVERED: 1 August 2015 – 31 August 2015

PREPARED BY: Doug Keinath, Lead Vertebrate Zoologist, WYNDD
Ian Abernethy, Vertebrate Zoologist, WYNDD
Nichole Bjornlie, Nongame Mammal Biologist, WGFD

SUMMARY

The white-tailed prairie dog (*Cynomys leucurus*; WTPD) is a regionally endemic species with 75% of its range in Wyoming (Seglund et al. 2004). WTPD was petitioned for listing under the US Endangered Species Act (ESA) in 2002, and the US Fish and Wildlife Service (USFWS) determined that listing was not warranted in 2010 (USFWS 2010). However, on 29 September 2014, a federal court in Montana remanded the decision to the USFWS, indicating that the 12-month finding did not meet the requirements of the ESA, in part by not supporting contentions that WTPD populations had not changed and were not threatened. This forced USFWS to re-consider the species for listing, which is currently in process. Range-wide monitoring of WTPD populations is not only a key component of an eventual listing decision in light of the recent court ruling, but is also a principle recommendation of the Interstate Prairie Dog Working Group (Seglund et al. 2004, WAFWA 2006). All states other than Wyoming have tested and adopted an occupancy-based monitoring approach to track changes in WTPD populations (Andelt and Seglund 2007), which they implemented in 2007 and 2010 and will be completed again in 2016. The Wyoming Natural Diversity Database (WYNDD) will conduct the Wyoming portion of this monitoring effort in the summer of 2016.

In August 2015, WYNDD conducted pilot WTPD surveys at 17 survey quadrats across the Shirley Basin in central Wyoming to test the efficacy of survey methods for the 2016 monitoring effort. These quadrats, and the associated survey methods, matched the design established in the approved interstate protocol (Andelt and Seglund 2007). The quadrats were

selected to encompass a range of habitat types, topographies, and likelihoods of being occupied by prairie dogs. Eight quadrats were surveyed both on foot and from an airplane on the same day to assess problems associated with each method and the comparability of results between the 2 methods. Surveyors classified sites into 1 of 4 categories: Prairie Dogs Observed, Fresh Burrows, Old Burrows, and No Activity.

Several habitat variables were recorded for each quadrat that could potentially impact WTPD detectability and occupancy. Cover in quadrats was estimated in 10% bins using 5 categories: tree, shrub, grass, bare ground, and water. If shrubs composed a measurable amount of cover (i.e., ≥10% of the quadrat), then the shrub species composing the largest portion of the overstory cover was identified, and overall shrub height in the quadrat was classified as short (<0.5 m), medium (0.5-1 m), tall (1-2 m), or huge (>2 m). Topography within the quadrat was classified as flat (unlikely to hinder observation of WTPD), rough (might hinder ability to see WTPD), or rugged (likely to obscure WTPD). Temperature was recorded in °F, and wind speed was estimated based on the Beaufort scale (Mather 2005). Other activity in the quadrat with the potential to influence observation of WTPD was noted, including evidence of other ground squirrels, presence of ant mounds, human activity, and predator activity.

Both aerial and ground surveys provided good information on prairie dog occupancy, although results differed somewhat. Actual observation of WTPD was difficult from the aerial surveys, with animals observed at only 1 of the 8 duplicate sites compared to 3 of those sites when surveyed from the ground. This resulted in only 25% of sites being placed into the same categories between the methods. However, fresh burrows were easily seen from the air, particularly during mid-morning. If we count both the Prairie Dogs Observed and Fresh Burrow categories as evidence of WTPD occupancy, then there was 75% concurrence between the methods. Even with this correction, however, 2 of 8 sites were still not classified the same between the methods. In both cases, no WTPD were observed from the ground, but fresh burrows were observed from the air. Thus, we believe that aerial surveys could potentially result in a higher estimate of occupancy than ground-based surveys. If this persists during actual survey efforts, this discrepancy can be corrected in post-hoc analyses.

Though sample size was low, several variables may influence WTPD occupancy. Most WTPD observations from both the ground and air occurred in terrain classified as flat and having short shrubs, generally with sagebrush representing the dominant canopy. Prairie dogs were not observed in any quadrats with >50% shrub cover, but observations seemed to be distributed evenly across shrub cover values below this level. Conversely, most WTPD observations occurred on quadrats with >50% grass cover and relatively low bare ground. We suggest that all variables recorded in this pilot effort be retained for the 2016 inventory and explored in construction of occupancy models.

Based on these pilot data, we expect that aerial surveys will be an effective supplement to ground-based surveys that can be used to assess occupancy at sites that cannot effectively be surveyed from the ground, for example, due to remoteness or land access issues. In order to implement this, however, it will require relaxing the restrictions on using only actual observation of prairie dogs as evidence of occupation. Thus, the formal estimates provided to the interstate inventory effort may have to be based solely on the ground-based surveys, with aerial effort used to extend the analysis of Wyoming populations.

LITERATURE CITED

Andelt, W. F., and A. E. Seglund. 2007. Protocol for conducting prairie dog occupancy surveys. White-tailed Prairie Dog and Gunnison's Prairie Dog Working Group, Fort Collins, Colorado, USA.

Mather, J. R. 2005. Beaufort wind scale. Pages 156-157 *in* Encyclopedia of World Climatology (J. E. Oliver, Editor). Springer, Dordrecht, The Netherlands.

Seglund, A. E., A. E. Ernst, M. Grenier, B. Luce, A. Puchniak, and P. Schnurr. 2004. White-tailed prairie dog conservation assessment. Western Association of Fish and Wildlife Agencies.

United States Fish and Wildlife Service [USFWS]. 2010. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the white-tailed prairie dog as endangered or threatened. Federal Register 75:30338-30363.

Western Association of Fish and Wildlife Agencies [WAFWA]. 2006. White-tailed prairie dog and Gunnison's prairie dog conservation strategy. Western Association of Fish and Wildlife Agencies.

EVALUATION OF ORAL SYLVATIC PLAGUE VACCINE IN WHITE-TAILED PRAIRIE DOGS (*CYNOMYS LEUCURUS*): YEAR 3

STATE OF WYOMING

NONGAME MAMMALS: White-tailed prairie dog

FUNDING SOURCE: Western Association of Fish and Wildlife Agencies
Wyoming State Legislature General Fund Appropriations
United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: June 1, 2013 – June 30, 2018

PERIOD COVERED: June 1, 2015 – April 15, 2016

PREPARED BY: Jesse Boulerice, Nongame Project Biologist

ABSTRACT

Since being unintentionally introduced to North America in the early 1900s, sylvatic plague has been a major contributor to the decline of populations of prairie dogs (*Cynomys* spp.). Several species of wildlife have either an obligate or facultative dependency on prairie dogs, which has prompted conservation efforts to focus on developing a deliverable and effective vaccine for sylvatic plague in these keystone species. Recently, the US Geological Survey developed a new oral vaccine shown to increase titers to sylvatic plague in prairie dogs within a laboratory environment. In 2013, the US Geological Survey initiated a nationwide, multi-agency collaborative endeavor to conduct field trials of this vaccine on 4 species of prairie dogs in the wild. The Nongame Program of the Wyoming Game and Fish Department agreed to participate in this effort, and began fieldwork specific to white-tailed prairie dogs (*C. leucurus*) in Wyoming. Our efforts from year 1 and 2 of this 3-year study are discussed in Boulerice and Grenier (2014) and Boulerice (2015), respectively. During year 3, we distributed vaccine-laden baits at 2 colonies of white-tailed prairie dog on the Pitchfork Ranch, Meeteetse in the same manner as in previous years. We then conducted mark-recapture surveys to generate estimates of abundance and survival to assess trends in population relative to vaccination efforts. During 5,120 trap days, we captured 1,067 unique white-tailed prairie dogs over four 16.2-ha plots and estimated the abundance of prairie dogs to be 386.47 (95% CI: 354.6-437.6) for plot A, 432.51 (95% CI: 410.6-464.4) for plot B, 253.04 (95% CI: 231.3-287.2) for plot C, and 242.48 (95% CI: 227.2-269.4) for plot D. We estimated the probability of annual survival of prairie dogs from 2014 to 2015 to be 37.8 (95% CI: 27.1-52.7) for plot A, 50.4 (95% CI: 37.9-67.1) for plot B, 33.9 (95% CI: 23.5-49.0) for plot C, and 42.5 (95% CI: 30.2-59.6) for plot D. These estimates suggest that abundance of prairie dogs increased more than 4-fold from 2013 to 2015. However, since no significant difference in abundance or survival was found between vaccinated

and unvaccinated individuals, we posit that these increases may be only partially due to vaccination efforts, and other environmental factors promoting reproduction and recruitment of young influenced the observed trends in the population. In an effort to assess populations of small mammals at the colonies, we captured North American deermice (*Peromyscus maniculatus*; *n* = 201), northern grasshopper mice (*Onychomys leucogaster*; *n* = 35), meadow voles (*Microtus pennsylvanicus*; *n* = 58), sagebrush voles (*Lemmiscus curtatus*; *n* = 11), and olive-backed pocket mice (*Perognathus fasciatus*; *n* = 4). We suggested that vaccine-laden baits may be an effective tool to mitigate the effects of plague in prairie dogs, at least at a small scale, based on our observed rates of distribution and consumption over the 3 years. In 2015, the Wyoming Game and Fish Department agreed to participate in an additional year of vaccine field trials. A comprehensive report on the efficiency of the vaccine specific to our study site in Meeteetse will be completed at the conclusion of 2016 surveys.

INTRODUCTION

Sylvatic plague is an exotic disease caused by bacteria *Yersinia pestis* that has affected a multitude of species of wildlife since being introduced to North America in the early 1900s (Gage and Kosoy 2005). Transmitted between hosts primarily by infected fleas, *Y. pestis* is especially prevalent within mammalian species of social nature, such as prairie dogs (*Cynomys* spp.; Antolin et al. 2002). With mortality rates of >90% in infected individuals, epizootic outbreaks of sylvatic plague often result in localized or even regional extirpation of colonies of prairie dogs (Cully and Williams 2001). The combined impacts of decades of poisoning, shooting, habitat loss, and sylvatic plague have diminished populations of prairie dogs nationwide, leading to range reduction of >98% for black-tailed prairie dogs (*C. ludovicianus*), and reductions are likely to be similar for other *Cynomys* spp. (Van Putten and Miller 1999, Miller and Cully 2001). Several other species of wildlife exhibiting an obligate or facultative dependency on prairie dogs also suffer from declines of this keystone species as a result of plague (Kotliar et al. 1999). Most notably, this includes the Endangered black-footed ferret (*Mustela nigripes*), a species that depends on prairie dogs as a primary source of food and shelter. Additionally, transmission of infected fleas from prairie dogs to ferrets is thought to be common, and ferrets are highly vulnerable to the direct effects of plague (Williams et al. 1994, Grenier et al. 2009, Jachowski and Lockhart 2009). Prompted by the severity of the threats posed by this disease to prairie dogs, ferrets, and affiliated communities, conservation efforts have focused on developing strategies and tools for combating sylvatic plague (Rocke et al. 2010, Abbott et al. 2012).

The US Geological Survey (USGS), University of Wisconsin, and Western Association of Fish and Wildlife Agencies (WAFWA) have recently begun evaluating a new vaccine for sylvatic plague (sylvatic plague vaccine, SPV; Rocke et al. 2010). SPV was designed to be delivered to prairie dogs via edible vaccine-laden baits, modeled after the oral vaccination program for rabies in carnivores (Abbott et al. 2012). As an alternative to dusting burrows with insecticide, vaccine-laden baits are purported to be cheaper to produce, easier to distribute, and less harmful to non-target species (Seery et al. 2003, Rocke et al. 2010, Abbott et al. 2012). This new management approach represents a proactive, rather than reactive, method to mitigate plague outbreaks in prairie dogs (Abbott et al. 2012). Laboratory tests have shown that baits are readily consumed by prairie dogs in a lab environment (Rocke et al. 2010). Once consumed, SPV has produced significant increases in antibody titers to sylvatic plague antigens as well as increased survival rates of prairie dogs when challenged with *Y. pestis* (Rocke et al. 2010). Encouraged by these results, the USGS, WAFWA, and the Black-footed Ferret Recovery and Implementation Team initiated a nationwide, multi-agency collaborative endeavor in 2013 to evaluate the effectiveness of these vaccine-laden baits in combating sylvatic plague in wild populations of 4 prairie dog species in North America.

A crucial component of these efforts to evaluate SPV includes assessing how species-specific differences between species of prairie dogs influence the effectiveness of the vaccine. Each species of prairie dog afflicted by plague exhibits variation in social behaviors, density of individuals within a colony, proximity of burrows, and configuration of colonies across the landscape that must be accounted for in designing an effective tool for mitigation of plague among species (Cully and Williams 2001, Antolin et al. 2002). Specifically, these differences are likely to produce critical distinctions in the rate of transmission of infected fleas between individuals, persistence of plague during enzootic periods, and frequency and lethality of epizootic outbreaks (Cully and Williams 2001, Antolin et al. 2002, Hanson et al. 2007). Likewise, rate of consumption of SPV baits and degree of antibiotic response are expected to vary by species and may require distinct density, pattern, and frequency of distribution of SPV to account for these differences (T. Rocke, personal communication). Accordingly, the collaborative project by the USGS seeks to elucidate these relationships between the vaccine, plague, fleas, and each species of prairie dog through field trials of SPV nationwide in order to maximize the success of SPV at combating the virulence and spread of sylvatic plague.

In conjunction with species-specific differences among prairie dogs, the dynamics of plague and SPV are further complicated by small rodent communities that also may play a veiled but significant role. For example, rodent species occurring within colonies such as the northern grasshopper mouse (*Onychomys leucogaster*) and North American deermouse (*Peromyscus maniculatus*) are capable of harboring infected fleas or even sustaining direct infection with *Y. pestis* without suffering the lethal effects of plague. Due to this reduced virulency in small rodents, these species are thought to be largely responsible for the persistence of the plague bacterium within an ecological system, especially during enzootic periods (Biggins and Kosoy 2001, Salkeld et al. 2010). In addition, movement of these alternative host species throughout and between colonies of prairie dogs may increase the spread of infection more so than by prairie dogs alone, whose movements tend to be localized to a particular set of burrows and small home range (Stapp et al. 2004, Salkeld et al. 2010). As a result of this increased connectivity, high abundances of small rodents have been linked to greater likelihood of plague outbreak within prairie dog colonies (Salkeld et al. 2010). These attributes of alternative hosts dictate that efforts to combat sylvatic plague in prairie dogs must include consideration of the influence of small rodents on plague and the success of SPV.

The Wyoming Game and Fish Department agreed to participate with the USGS and other agencies in the collaborative project to test the effectiveness of SPV in populations of wild prairie dogs. We selected colonies of white-tailed prairie dogs (*C. leucurus*; WTPD) near Meeteetse as the site of SPV trials in Wyoming, due to a well-documented history with prairie dogs, plague, and ferrets in the region (WGFD 1990, Menkens and Anderson 1991). WTPD are the least social of all of the species of prairie dog in North America and, therefore, are likely to exhibit species-specific differences that could be crucial to successfully combating plague with SPV (Cully and Williams 2001, Antolin et al. 2002). As 1 of only 2 sites participating in this endeavor to focus on WTPD, our efforts are fundamental in assessing the use of SPV as a tool for mitigating the impacts of sylvatic plague specific to this species, which ranges throughout much of Wyoming. The overall goal of this project in Wyoming was to determine if the vaccine will result in significant increases in survival rates as compared to unvaccinated individuals of WTPD (T. Rocke, personal communication). Following a protocol standardized for use among all agencies participating in the project, a mark-recapture approach was employed to compare survival rates between prairie dogs presented with vaccine-laden or placebo baits over a 3-year period. Our results from Meeteetse will be used by the USGS to inform a multi-species assessment.

During the summer of 2015, we completed the 3rd year of surveys on four 16-ha plots at 2 distinct colonies (2 plots per colony, colonies AB and CD) of WTPD at our study site. Following the same methods used in 2014, we completed 3 main objections. First, we estimated the abundance of WTPD in 2015 and compared these estimates obtained in 2013 and 2104 in order to evaluate differences in abundance as a result of vaccination. Second, we assessed the influence of vaccination on survival of WTPD by comparing estimates between animals receiving SPV and those receiving a placebo. Third, we evaluated the influence alternative hosts for plague may have on our study sites by measuring the abundance of small mammals within the vaccinated areas. The results of these objectives are detailed below. Efforts from year 1 and 2 of this 3-year study are discussed in Boulerice and Grenier (2014) and Boulerice (2015), respectively.

METHODS

During mid-June through mid-August 2015, we conducted the 3rd year of surveys on colonies of WTPD at Pitchfork Ranch, approximately 24 km west of Meeteetse. We surveyed the same colonies that were surveyed in 2013 and 2014 (Boulerice and Grenier 2014, Boulerice 2015). We surveyed a pair of 16.2-ha rectangular plots separated by ≥200 m on each selected colony. For naming convenience, plots established within colony AB were labeled Plot A and Plot B, while plots within colony CD were labeled Plot C and Plot D (Figure 1).

Prior to distribution of vaccine-laden baits and capturing WTPD, we assessed abundance of small mammals by establishing trapping grids within each of the 4 plots for 2015. Our trapping grid in 2015 was identical to the grids surveyed in 2014. Specifically, each trapping grid for small mammals (SMG) was centered within each respective plot and labeled accordingly (i.e., SMG-A was centered on plot A, SMG-B was centered on plot B, etc.; Figure 1). Each SMG consisted of 132 small mammal traps (339A non-folding trap, Sherman Trap, Inc., Tallahassee, FL) spaced 16 m apart in a 12 x 11 array. We trapped small mammals at each grid for 4 consecutive nights. We baited all traps with steel cut oats at approximately 1700 and returned to process captures the following morning at 0800. Each captured individual was marked with a single ear tag (1005-1, National Band and Tag Co., Newport, KY). We collected hair and whisker samples and recorded sex, age, and weight from all captured animals. We collected blood samples from adult animals >15g. Biological samples were sent to USGS for analysis.

We then distributed baits supplied by the USGS between 4-5 June on plots A and B, and between 1-2 July on plots C and D, as was done in 2014 (Boulerice 2015). Baits were provided in 2 forms, treatment (i.e., with vaccine) and placebo (i.e., without vaccine). Plots that received either the treatment or placebo form in previous years received the same form in 2015. USGS pre-assigned baits to each plot in a blind manner, such that field personnel were unaware whether they were distributing treatment or placebo baits to prevent any bias in distribution. We distributed baits by foot evenly along transects at a rate of 100 pieces of bait per ha for a total of 1,600 baits per plot.

We trapped WTPD at each plot approximately 2 weeks following the distribution of the baits. We captured and uniquely marked WTPD and collected flea, hair, and blood samples from individuals to assess flea load and composition, consumption of bait, and antibody titers of plague antigens. Specifically, we evenly spaced 160 trapping stations over each plot at a rate of 10 stations per ha. Each trapping station received a Tomahawk live-trap (Model #102 or #103, Tomahawk Live Trap, LLC, Hazelhurst, WI). We locked open traps for 6 days prior to trapping and pre-baited with sweet horse feed (C.O.B with Molasses, Manna Pro Products LLC, Chesterfield, MI). After pre-baiting, we trapped each set of paired plots for 8 consecutive mornings for a total of 1,280 trapping occasions per plot (160 traps x 8 occasions). Each morning, between 0630 and 0800, we baited, opened, and reset traps. We began checking traps for captures at 1000 and closed all traps for the day by 1130.

Upon capture, we safely transported prairie dogs to a centralized processing station. We briefly anesthetized prairie dogs by placing animals into a sealed chamber filled with isoflurane gas. Once anesthetized, we collected flea, hair, whisker, and blood samples from prairie dogs. Additionally, we marked each individual with passive integrated transponders (PIT tags; AVID Microchip I.D. Systems, Folsom, LA) and one ear tag in each ear (1005-1, National Band and Tag Co., Newport, KY). We also recorded sex, age, and weight of each animal. We allowed each individual to recover from the effects of isoflurane and released animals at the location of capture. We sent all biological samples to the USGS for analysis.

We estimated the abundance of prairie dogs at each plot in 2015 by using Huggins conditional likelihood formulation in program MARK (Huggins 1989, White and Burnham 1999). Our candidate model set included model combinations that considered the effect of individual heterogeneity (π), time, age (adult, subadult), sex, number of nearby burrows (bur), age x time, sex x time, and bur x time on probability of capture (*p)* and recapture (*c*; Otis et al. 1978, White et al. 1982). We calculated number of nearby burrows by averaging the number of active burrows within 20 m of each trap in which an individual was captured. We calculated the weight of each model based on Akaike's Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). Estimates and unconditional standard error of abundance were calculated for each plot by weighted model-averaging across all models (Burnham and Anderson 2002). We used a log-transformation to calculate 95% confidence intervals (95% CI) associated with each model-averaged estimate of abundance (Chao 1987).

We estimated the probability of survival of prairie dogs at each plot by using the Cormack-Jolly-Seber formulation (Cormack 1964, Jolly 1965, Seber 1965) in MARK. Our candidate model set for this analysis included model combinations that considered the effect of time, age (adult, subadult), sex, age x time, and sex x time on probability of capture (*p*) and probability of survival (Φ) from 2013 to 2014. As above, we calculated the weight of each model based on AIC*c* (Burnham and Anderson 2002). Estimates and unconditional standard error of abundance were calculated for each plot by weighted model-averaging across all models (Burnham and Anderson 2002).

RESULTS

During small mammal trapping, we captured 306 unique individuals, consisting of 201 North American deermice, 4 olive-backed pocket mice (*Perognathus fasciatus*), 35 northern grasshopper mice, 58 meadow voles (*Microtus pennsylvanicus*), and 11 sagebrush voles (*Lemmiscus curtatus*). Based on more detailed examined of morphologic features, we determined that voles captured in 2014 identified as prairie voles (*M. ochrogaster*) were instead meadow voles. Sagebrush voles were found only in 2015. We compared annual small mammal captures by grid in Table 1.

We distributed vaccine-laden baits at a density of 100 baits per ha over 64.7 total ha at a rate of 1.3 ha per person per hour. After 2-3 days, baits were no longer observed within the plots. Scat from prairie dogs, distinctively colored the same shade of red as the dye of the baits, was readily observed at the majority of active burrows.

In 5,120 trap occasions, we captured prairie dogs 2,830 times for a capture rate of 0.55 prairie dogs per trap occasion. Of those, 1,067 were unique individuals comprised of 502 males and 565 females (m:f: 0.89:1). Number of individuals captured at each plot was 302 for A, 367 for B, 192 for C, and 206 for D. A comparison of captures by plot for each of the 3 years is displayed in Table 2. We captured individuals 2.7 times on average (SE ±0.05, range: 1-8) over 8 sampling occasions, and 66% of individuals were recaptured at least once. We collected blood, hair, and whisker samples from 246 individuals, which were sent to the USGS for analysis.

We estimated the abundance of prairie dogs in 2015 to be 386.47 individuals (95% CI: 354.6-437.6) for plot A, 432.51 individuals (95% CI: 410.6-464.4) for plot B, 253.04 individuals (95% CI: 231.3-287.2) for plot C, and 242.48 individuals (95% CI: 227.2-269.4) for plot D. Comparisons of estimates of abundance for each plot by year are shown in Figure 2. Top models for estimates of abundance for 2015 are shown in Table 3. During analysis, we removed those models that included the effect of π and *c* together, as these models generated estimates with standard errors that were too large to allow for meaningful comparison between years. This inflated variation in estimates of abundance often occurs within the Huggins formulation when *p* is close to 0 for some animals (Pollock 2002), which is likely the case here.

Based on the estimates of abundance for 2015, we estimated density of prairie dogs (i.e., individuals per ha) to be 23.9 (95% CI: 21.92-27.04) for plot A, 26.7 (95% CI: 25.4-28.8) for plot B, 15.6 (95% CI: 14.3-17.8) for plot C, and 15.0 (95% CI: 14.0-16.7) for plot D. Density comparisons between our study site and historical densities reported for throughout Wyoming are shown in Table 4.

We estimated the probability of annual survival of prairie dogs from 2014 to 2015 to be 37.8 (95% CI: 27.1-52.7) for plot A, 50.4 (95% CI: 37.9-67.1) for plot B, 33.9 (95% CI: 23.5-49.0) for plot C, and 42.5 (95% CI: 30.2-59.6) for plot D. Estimates are displayed graphically in Figure 3. Top models for estimates of survival for 2015 are shown in Table 5.

DISCUSSION

Our estimates from each of the 3 years suggested that abundance has increased roughly 4-fold since vaccine-distribution was initiated in 2013 (Figure 2). This increase in abundance is supported by anecdotal evidence from the field, specifically an apparent increase in visual observations of prairie dogs from one year to the next. Additionally, local landowners report that prairie dogs numbers are the highest seen in recent years (L. Baker, personal communication, A. Hogg, personal communication). Over the 3-year period, our estimates of density per hectare of prairie dogs at each colony increased from slightly below the range typical of healthy colonies of WTPD (2013) to a density within the range of estimates from other studies throughout Wyoming (2014) and finally to a density that represents some of the highest reported for this species in Wyoming (2015; Table 4).

While our metrics used to assess abundance support a significant increase in prairie dogs during each year of survey, the cause of this increase remains unresolved. Increases may be due in part to distribution of SPV across the treatment plots of each colony. Responses to SPV, including increases in antibiotic resistance to the plague bacterium, are expected to increase the survival and ultimately the abundance of prairie dogs on vaccinated colonies (Rocke et al. 2010). However, since abundances increased ubiquitously across all of our study area, we did not find support for a significant difference in abundance between paired-plots, or specifically plots receiving the SPV and plots receiving placebo baits, as would be expected if SPV was the primary driver of increased abundance. Likewise, as in 2014, although our estimates of survival on paired plots between 2014 and 2015 differed slightly from each other, the overlap in confidence intervals suggests that this difference was not significant (Figure 3). Therefore, while SPV may play a role in the increase in abundance we observed, other factors are likely to have a contributed significantly to the change. For example, the annual trajectory of abundance we have observed at the study site over 3 years suggests that prairie dogs are experiencing exponential growth (Figure 2). This natural growth pattern may have been prompted by increases in reproductive activity and recruitment of young as a result of optimal weather conditions and/or high availability of food resources over the past 3 years at Pitchfork Ranch. As prairie dog colonies continue to grow and become less isolated as the result of expanding colony boundaries (Boulerice, personal observation), the increased in abundance specifically within our surveyed plots may be partially explained by immigration of individuals from neighboring colonies. In conjunction, supplemental feeding from our trapping efforts (i.e., horse feed used to bait animals into traps) may have endowed some nutritional value to prairie dogs. However, the amount and duration of this food source seems unlikely to provide sizeable benefit.

Our assessment of small rodent populations suggests that alternative hosts of sylvatic plague, most notably North American deermice and northern grasshopper mice, could play a significant role in the dynamics of the disease and vaccination efforts within our colonies. Extrapolation of our estimates of abundance suggests an average of 228.6 deermice occurred within the confines of each plot (16.2 ha), which represents approximately an 80% increase from estimates in 2014 (Boulerice 2015). Likewise, our estimates for northern grasshopper mice increased from only a few individuals per plot in 2014 (Boulerice 2015), to nearly 40 individuals per plot. The high density of both of these species likely accelerates the spread of fleas throughout our colonies, while simultaneously providing a suitable alternative host for the persistence of plague during enzootic periods. Additionally, the high density of deermice undoubtedly reduced the number of SPV baits available to prairie dogs, as deermice also readily consume baits at our colonies. SPV consumption by non-target species such as deermice may provide immunization from plague, and efforts to quantify the benefits to non-target species are currently ongoing within the collaborative project with USGS (T. Rocke, personal communication). However, consideration of the amount of non-target consumption, likely correlated to abundance, is vital to determining the appropriate density and pattern of distribution of SPV for vaccinating prairie dogs. The influence of the other small rodent species we detected on our plots, including olive-backed pocket mice, meadow voles, and sagebrush voles, is unknown, although these species are also capable of carrying fleas and consuming baits.

Although SPV holds promise, some preliminary observations from our project suggest that effective use of vaccine-laden baits may be limited to small-scale application. We dispersed a high concentration of baits (approximately 100 baits per ha) by foot at a rate of roughly 1.32 ha per hour in both 2013 and 2014. Although this method may be less labor intensive than the alternative approach of dusting with insecticide, considerable effort would still be required to vaccinate large colonies (i.e., >16 ha in size). We acknowledge that vaccine-laden baits have been developed with the intent of being dispersed by motor-vehicle or aircraft, which may increase rates of distribution (Abbott et al. 2012). However, using this approach likely comes at a substantial increase in cost of distribution (e.g., cost of manpower versus flight time). Additionally, price of production of vaccine-laden baits may be higher than originally expected (T. Rocke, personal communication). This unanticipated cost may limit the feasibility of SPV from being used at a large-scale unless density of baits or cost of production and distribution is reduced. However, efforts are underway to find a company willing to mass-produce the vaccine-laden baits at a reduced cost (T. Rocke, personal communication). Nevertheless, as currently structured, SPV may become a valuable tool for localized management in the near future.

As in 2014, our results from 2015 failed to show a clear relationship between increased survival or abundance of WTPD and SPV. Importantly, this lack of correlation does not indicate SPV is ineffective at combating plague. Two assumptions must be met within the system in order for vaccination with SPV to result in significant changes in survival or abundance of prairie dogs. First, plague must be present in the population. Given the well-documented history of drastic declines in populations of WTPD in the Meeteetse region as a result of plague, as well as documented persistence of the disease long after epizootics, we are confident that this assumption is met and *Y. pestis* remains present within our study site (WGFD 1990, Menkens and Anderson 1991). Second, the effects of plague must sufficiently suppress the population, in terms of a reduction in survival, reproduction, recruitment, etc. such that the liberation from suppression after immunization is measurable. During enzootic periods, *Y. pestis* can persist either within primary hosts like prairie dogs at low levels without noticeable effects on the species or within alternative hosts (Antolin et al. 2002). With no evidence of a recent epizootic outbreak and an abundance of alternative hosts, we believe that our study site is in the midst of an enzootic period where the effects of plague are likely subdued, and, therefore, this second assumption may not be met. Therefore, a correlation between consumption of SPV and increased survival or abundance is not expected to occur. Accordingly, our assessment of effectiveness of SPV is based instead on capacity to deliver the vaccine to prairie dogs (rate of consumption, ease of distribution) and antibiotic response to plague antigens (results pending). While the former of these factors thus far suggests that SPV has the potential to be an effective tool to combating plague in WTPD at least on a small scale, we anticipate that the final results of this project being compiled and analyzed by the USGS collaborators will allow for a more thorough assessment. We note that other field sites participating in the SPV field trials have experienced epizootic plague outbreaks during SPV application (T. Rocke, personal communication). Therefore, a direct comparison of survival and abundances from prairie dogs challenged by plague will be available once all results are interpreted by the USGS.

At the end of field surveys in 2015, the USGS solicited interest from participating agencies to conduct a 4th year of SPV field trails in 2016 in order to increase the number of time steps in estimates of survival and abundance. The Department agreed to perform these additional surveys at the Pitchfork Ranch study site. A comprehensive report encompassing all 4 years of SPV-related efforts will be completed at the conclusion of the 2016 surveys.

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LITERATURE CITED

Abbott, R. C., J. E. Osorio, C. M. Bunch, and T. E. Rocke. 2012. Sylvatic plague vaccine: a new tool for conservation of threatened and endangered species? Ecohealth 9:243-250.

Antolin, M. F., P. Gober, B. Luce, D. E. Biggins, W. E. Van Pelt, D. B. Seery, M. Lockhart, and M. Ball. 2002. The influence of sylvatic plague on North American wildlife at the landscape level, with species emphasis on black-footed ferret and prairie dog conservation. Transactions of the 67th North American wildlife and natural resources conference, Washington, D.C., USA.

Biggins, D. E., and M. Y. Kosoy. 2001. Influences of introduced plague on North American mammals: implications from ecology of plague in Asia. Journal of Mammalogy 82:906-916.

Biggins, D. E., B. J. Miller, L. R. Hanebury, B. Oakleaf, A. H. Farmer, R. Crete., and A. Dood. 1993. A technique for evaluating black-footed ferret habitat. Pages 73-88 *in* Proceedings of the Symposium on the Management of Prairie Dog Complexes for the Reintroduction of the Black-footed Ferret (J. L. Oldemeyer, D. Biggins, B. J. Miller, and R. Crete, Editors). US Fish and Wildlife Service, Biological Report 13, Washington, D.C., USA.

Boulerice, J. 2015. Evaluation of oral sylvatic plague vaccine in white-tailed prairie dogs: year two. Pages 305-328 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona, and C. K. Rudd, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Boulerice, J., and M. Grenier. 2014. Evaluation of oral sylvatic plague vaccine in white-tailed prairie dogs: year one. Pages 431-452 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Spring Science Business Media, New York, New York, USA.

Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. Biometrics 43:783-791.

Cormack, R. M. 1964. Estimates of survival from the sighting of marked animals. Biometrika 51:429-438.

Cully, J. F., and E. S. Williams. 2001. Interspecific comparisons of sylvatic plague in prairie dogs. Journal of Mammalogy 82:894-905.

Gage, K. L., and M. Y. Kosoy. 2005. Natural history of plague: perspectives from more than a century of research. Annual Review of Entomology 50:505-528.

Grenier, M., S. W. Buskirk, and R. Anderson-Sprecher. 2009. Population indices versus correlated density estimates of black-footed ferret abundance. Journal of Wildlife Management 73:669-676.

Hanson, D. A., H. B. Britten, M. Restani, and L. R. Wasburn. 2007. High prevalence of *Yersina pestis* in black-tailed prairie dog colonies during an apparent enzootic phase of sylvatic plague. Conservation Genetics 8:789-795.

Huggins, R. M. 1989. On the statistical analysis of capture-recapture experiments. Biometrika 76:133-140.

Jachowski, D. S., and J. M. Lockhart. 2009. Reintroducing the black-footed ferret *Mustela nigripes* to the Great Plains of North America. Small Carnivore Conservation 41:58-64.

Jolly, G. M. 1965 Estimates of population parameters from multiple recapture data with both death and dilution – deterministic model. Biometrika 50:225-247.

Kotliar, N. B., B. W. Baker, and A. D. Whicker. 1999. A critical review of the assumptions about the prairie dog as a keystone species. Environmental Management 24:177-192.

Menkens, G. E., Jr., and S. H. Anderson. 1988. Estimation of small-mammal population size. Ecology 69:1952-1959.

Menkens, G. E., and S. H. Anderson. 1989. Temporal-spatial variation in white-tailed prairie dog demography and life histories in Wyoming. Canadian Journal of Zoology 67:343-349.

Menkens, G. E., and S. H. Anderson. 1991. Population dynamics of white-tailed prairie dogs during an epizootic of sylvatic plague. Journal of Mammalogy 72:328-331.

Miller, S. D., and J. F. Cully. 2001. Conservation of black-tailed prairie dogs (*Cynomys ludovicianus*). Journal of Mammalogy 82:889-893.

Orabona-Cerovski, A. 1991. Habitat characteristics, population dynamics, and behavioral interactions of white-tailed prairie dogs in Shirley Basin, Wyoming. Thesis. University of Wyoming, Laramie, USA.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference for capture data on closed animal populations. Wildlife Monographs 62:3-135.

Pollock, K. H. 2002. The use of auxiliary variables in capture-recapture modeling: an overview. Journal of Applied Statistics 29:85-102.

Rocke, T. E., N. Pussini, S. R. Smith, J. Williamson, B. Powell, and J. E. Osorio. 2010. Consumption of baits containing raccoon pox-based plague vaccines protects black-tailed prairie dogs (*Cynomys ludovicianus*). Vector-Borne and Zoonotic Diseases 10:53-58.

Salkeld, D. J., M. Salthe, P. Stapp, and J. H. Jones. 2010. Plague outbreaks in prairie dog populations explained by percolation thresholds of alternate host abundance. Proceedings of the National Academy of Sciences of the United States of America 32:14247-14250.

Seber, G. A. F. 1965. A note on the multiple recapture census. Biometrika 52:249-259.

Seery, D. B., D. E. Biggins, J. A. Montenieri, R. E. Enscore, D. T. Tanda, and K. L. Gage. 2003. Treatment of black-tailed prairie dog burrows with deltamethrin to control fleas (Insecta: Siphonaptera) and plague. Journal of Medical Entomology 40:718.

Stapp, P., M. F. Antolin, and M. Ball. 2004. Patterns of extinction in prairie dog metapopulations: plague outbreaks follows El Niño events. Frontiers in Ecology and Environment 2:235-240.

Van Putten, M., and S. D. Miller. 1999. Prairie dogs: the case for listing. Wildlife Society Bulletin 27:1110-1120.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory Report LA 8787-NERP, Los Alamos, New Mexico, USA.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 Supplement:120-138.

Williams, E., K. Mills, D. Kwiatkowski, E. T. Thorne, and A. Boerger-Fields. 1994. Plague in a black-footed ferret (*Mustela nigripes*). Journal of Wildlife Diseases 30:581-585.

Wyoming Game and Fish Department [WGFD]. 1990. A Cooperative Management Plan for Black-footed Ferrets at Meeteetse. Black-footed Ferret Advisory Team. Wyoming Game and Fish Department, Lander, USA.

Table 1. Captures of small mammals on grids at Pitchfork Ranch, Meeteetse, conducted June-July 2015. We captured small mammals at 4 grids located in the center of each of the 4 plots: small mammal grid (SMG) A, B, C, and D. Values represent number of unique animals captured in 8 trapping occasions.

Species	SMG-A	SMG-B	SMG-C	SMG-D	Total
Peromyscus maniculatus	67	39	47	48	201
Microtus pennsylvanicus	10	5	43	0	58
Onychomys leucogaster	12	2	13	8	35
Lemmiscus curtatus	0	0	5	6	11
Perognathus fasciatus	2	2	0	0	4
Total	91	48	108	62	309

Table 2. Captures of white-tailed prairie dogs (*Cynomys leucurus*) on each of 4 plots at Pitchfork Ranch, Meeteetse, from surveys conducted June-July 2013, 2014, and 2015.

Plot	**Total marked**	Recaptures	Percent recaptured	New	**Total marked**	Recaptures	Percent recaptured	New	**Total marked**
	2013	2014				2015			
A	**75**	37	0.49	79	**116**	37	0.31	265	**302**
B	**85**	41	0.48	79	**120**	58	0.48	309	**367**
C	**57**	16	0.28	79	**95**	30	0.33	162	**192**
D	**65**	14	0.21	101	**115**	47	0.41	159	**206**
Total	**282**	108	0.38	338	**446**	172	0.39	895	**1067**

Table 3. Results from Huggins closed population models to estimate abundance of white-tailed prairie dogs (*Cynomys leucurus*) at Pitchfork Ranch, Meeteetse, June-August 2013-2015. Our candidate model set included models combinations that considered the effect of individual heterogeneity (π), time, age (adult, subadult), sex, number of nearby burrows (Bur), age x time, sex x time, and bur x time on probability of capture (*p)* and recapture (*c*; Otis et al. 1978, White et al. 1982). Only the top 6 models are shown for each year. We calculated the weight of each model based on Akaike's Information Criterion for small sample size (AIC*c*; Burnham and Anderson 2002). Estimates and unconditional standard error of abundance were calculated for each plot by weighted model-averaging across all models (Burnham and Anderson 2002). Model average estimates shown in bold were derived from the entire dataset.

Model	AIC*c*	Delta AIC*c*	AIC*c* weight	$\hat{N}(\widehat{SE})$ Plot A	$\hat{N}(\widehat{SE})$ Plot B	$\hat{N}(\widehat{SE})$ Plot C	$\hat{N}(\widehat{SE})$ Plot D
π+Time+p(Bur)	10289.61	0.00	0.353	387.05 (20.23)	433.82 (14.01)	252.63 (13.80)	242.34 (10.20)
π+Time+p(Sex)+p(Bur)	10290.18	0.57	0.265	387.54 (20.69)	432.40 (13.46)	254.88 (14.22)	243.94 (10.87)
π+Time+p(Age)+p(Bur)	10291.57	1.96	0.132	387.41 (20.34)	433.76 (14.04)	252.51 (13.81)	242.22 (10.17)
π+Time+p(Age)+p(Sex)+p(Bur)	10292.18	2.57	0.098	387.75 (20.82)	432.37 (13.48)	254.81 (14.24)	243.87 (10.86)
π+Time	10293.03	3.43	0.064	381.49 (21.05)	429.17 (13.07)	249.41 (13.21)	239.22 (9.43)
π+Time+p(Sex)	10293.73	4.12	0.045	380.90 (21.28)	428.02 (12.62)	251.13 (13.53)	240.13 (9.87)
MODEL AVERAGE				**386.48 (20.58)**	**432.51 (13.76)**	**253.04 (13.89)**	**242.48 (10.34)**

Table 4. Densities of white-tailed prairie dogs (*Cynomys leucurus*) from Pitchfork Ranch, Meeteetse 2013-2015 compared to historical densities reported for throughout Wyoming.

Prairie dogs per ha	Region	Source
4.8 – 5.2	**Meeteetse**	**This project 2013**
6.3 – 9.2	**Meeteetse**	**This project 2014**
15.0 – 26.7	**Meeteetse**	**This project 2015**
5.1 – 15.6	Laramie and Meeteetse	Menkens and Anderson 1991
4.0 – 19.1	Laramie and Meeteetse	Menkens and Anderson 1989
13.9 – 20.9	Meeteetse	Menkens and Anderson 1988
5.7 – 16.0	Meeteetse	Biggins et al. 1993
0.12 – 29.0	Shirley Basin	Orabona-Cerovski 1991

Table 5. Results from Comack-Jolly-Seber open population models to assess survival of white-tailed prairie dogs (*Cynomys leucurus*) at Pitchfork Ranch, Meeteetse, between July-August 2014 and 2015. Our candidate model set included model combinations that considered the effect of time, age (adult, subadult), sex, age x time, and sex x time on probability of capture (*p*), and probability of survival (Φ). Only the top 6 models are shown. We calculated the weight of each model based on Akaike's Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). Estimates and of survival were calculated for each plot by weighted model-averaging across all models (Burnham and Anderson 2002). 95% confidence intervals (95% CI) for each estimate of survival are reported in parentheses. Model average estimates shown in bold were derived from the entire dataset.

Model	AIC*c*	Delta AIC*c*	AIC*c* weight	$\hat{\Phi}$(95% CI) Plot A	$\hat{\Phi}$(95% CI) Plot B	$\hat{\Phi}$(95% CI) Plot C	$\hat{\Phi}$(95% CI) Plot D
Φ(Plot,Sex,Age,Sex*t,Age*t),p(Sex,Age,Sex*t,Age*t)	1248.45	0.00	0.303	0.35 (0.28,0.43)	0.47 (0.39,0.55)	0.31 (0.24,0.41)	0.39 (0.32,0.48)
Φ(Plot,Sex,Sex*t,Age*t),p(Time,Sex,Sex*t)	1251.35	2.99	0.073	0.33 (0.26,0.41)	0.44 (0.37,0.53)	0.29 (0.22,0.38)	0.37 (0.3,0.45)
Φ(Plot,Sex,Age,Age*t),p(Time,Sex,Age,Sex*t)	1251.91	3.45	0.055	0.33 (0.26,0.42)	0.45 (0.37,0.53)	0.29 (0.22,0.38)	0.37 (0.29,0.46)
Φ(Plot,Time,Sex,Age,Sex*t,Age*t),p(Age)	1252.05	3.60	0.051	0.43 (0.35,0.54)	0.58 (0.49,0.69)	0.39 (0.31,0.51)	0.5 (0.4,0.63)
Φ(Plot,Time,Sex,Age,Sex*t,Age*t),p(Sex,Age,Sex*t,Age*t)	1252.29	3.83	0.045	0.35 (0.28,0.44)	0.47 (0.39,0.56)	0.31 (0.24,0.41)	0.39 (0.31,0.49)
Φ(Plot,Sex,Age,Sex*t,Age*t),p(Sex,Age,Sex*t)	1252.45	4.09	0.040	0.39 (0.28,0.54)	0.52 (0.39,0.69)	0.34 (0.24,0.48)	0.43 (0.32,0.58)
MODEL AVERAGE				**0.37 (0.27-0.53)**	**0.50 (0.38,0.67)**	**0.34 (0.23,0.49)**	**0.42 (0.30,0.60)**

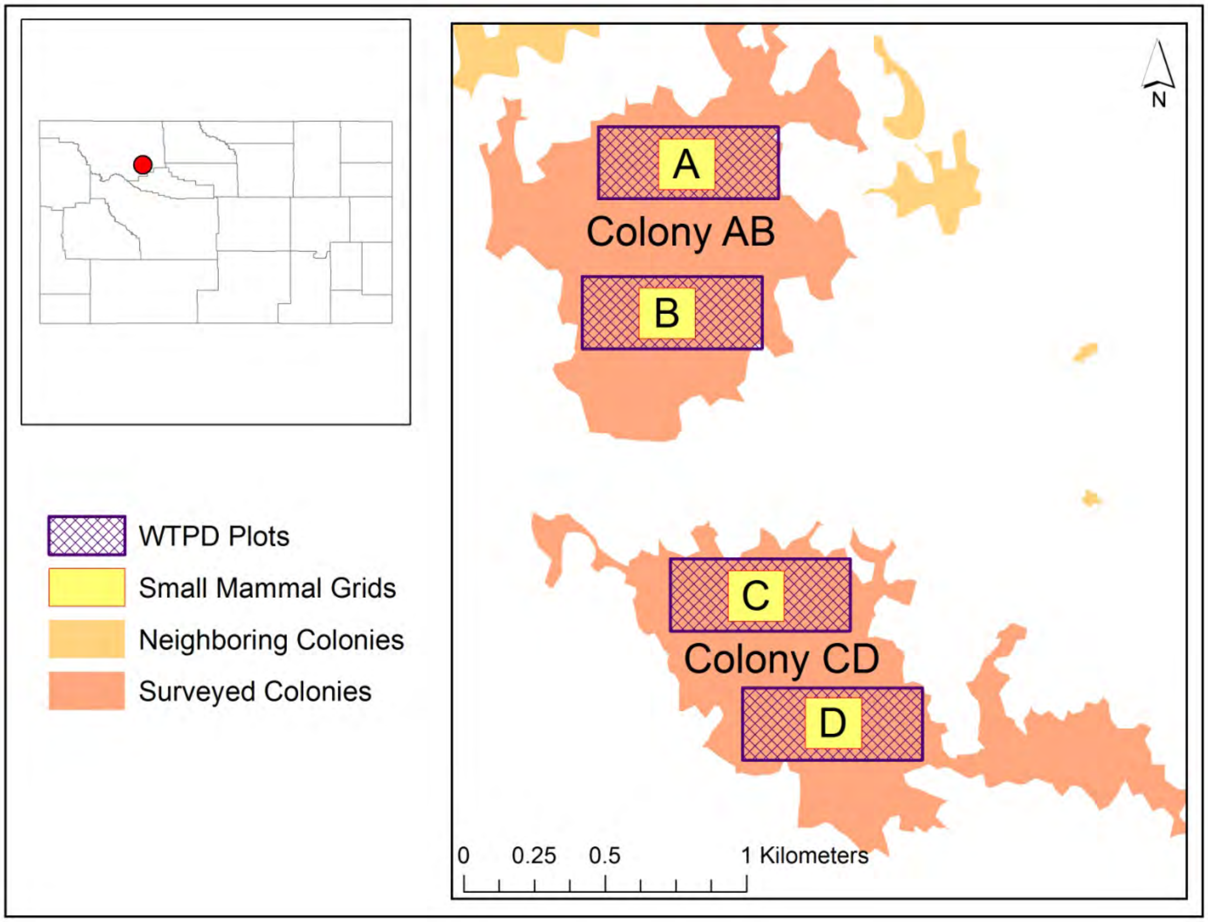

Figure 1. Location of colonies, plots, and small mammal grids at Pitchfork Ranch, Meeteetse, 2015. Plots were paired such that 1 plot in each colony received the vaccine-laden baits, while the other received a placebo (paired-plots). Baits were distributed in blind manner. Small-mammal grids were located at center of each plot and trapped prior to distribution of baits.

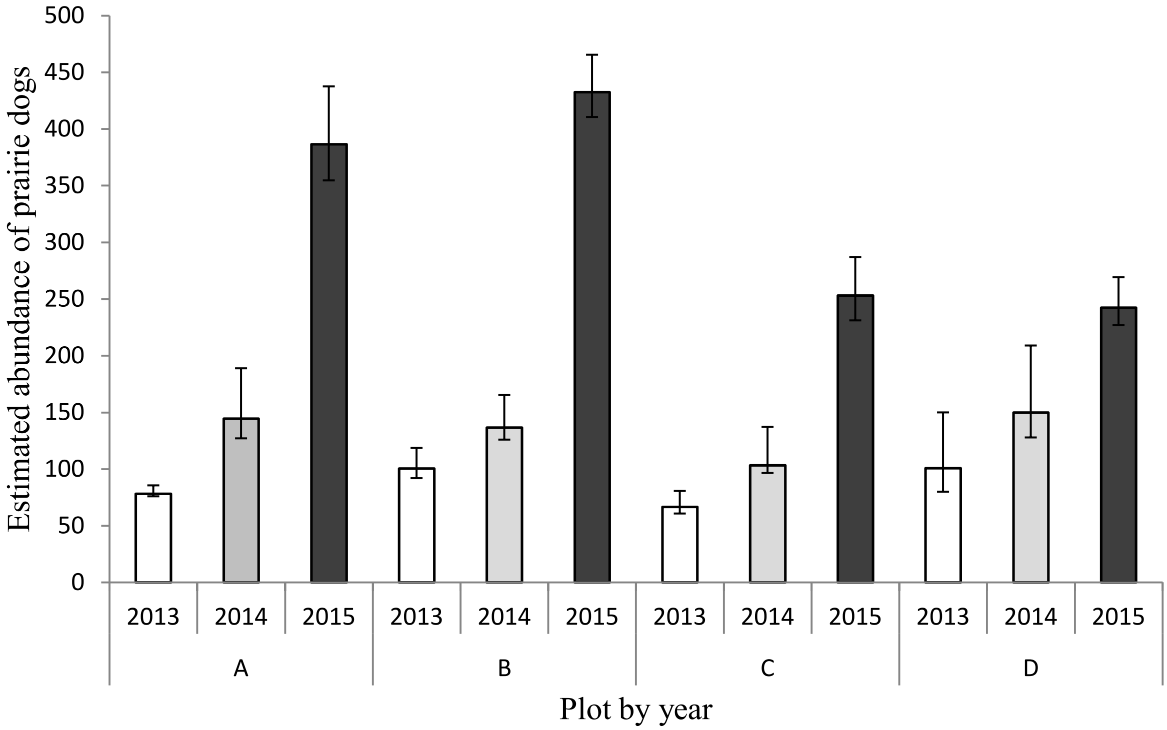

Figure 2. Estimates of abundance of white-tailed prairie dogs (*Cynomys leucurus*) within each plot at Pitchfork Ranch, Meeteetse, June-August 2013, 2014, and 2015. Estimates were derived under closed population models using Huggins conditional likelihood formulation (Huggins 1989, White and Burnham 1999). Error bars indicate log-transformed 95% confidence intervals for each estimate (Chao 1987). All estimates were obtained by weighted modeling averaging based on AIC*c* weights.

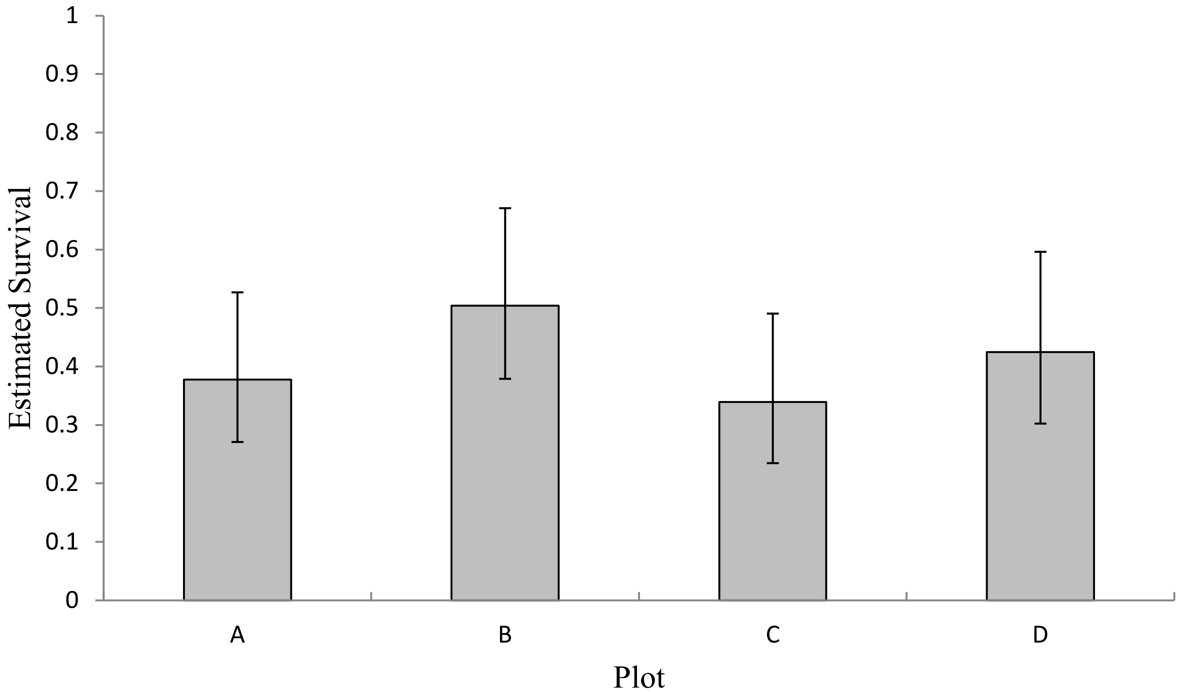

Figure 3. Estimated probability of annual survival of white-tailed prairie dogs (*Cynomys leucurus*) within each plot at Pitchfork Ranch, Meeteetse, from June-August 2014 to 2015. Estimates were derived using the Cormack-Jolly-Seber formulation (Cormack 1964, Jolly 1965, Seber 1965). Error bars indicate 95% confidence interval of each estimate.

BLACK-TAILED PRAIRIE DOG (*CYNOMYS LUDOVICIANUS*) STATEWIDE INVENTORY

STATE OF WYOMING

NONGAME MAMMALS: Black-tailed prairie dog

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: 1 July 2014 – 30 June 2017

PERIOD COVERED: 1 July 2014 – 30 June 2017

PREPARED BY: Nichole Bjornlie, Nongame Mammal Biologist

SUMMARY

Black-tailed prairie dogs (*Cynomys ludovicianus*), although historically abundant and widely distributed, are susceptible to a number of threats, including habitat loss, epizootic diseases, and targeted control programs, that have lead to their decline (Van Pelt 1999). In 2011, in response to these declines and a subsequent petitions to list the species as Threatened or Endangered under the federal Endangered Species Act (USFWS 2000, 2009), the Interstate Prairie Dog Conservation Team recommended standard survey protocols that could be utilized range-wide and would be consistent among states, with monitoring occurring at 3-5-year intervals (McDonald et al. 2011). In 2015, the Wyoming Game and Fish Department (Department), with the Western Association of Fish and Wildlife Agencies, contracted with Western EcoSystems Technology, Inc. (WEST, Inc.) to conduct a statewide inventory of black-tailed prairie dogs in Wyoming The following is a summary of the report by McDonald et al. (2015); for the full report, please see www.west-inc.com/wildlife-life-monitoring-and-research or contact the Department to request a copy.

McDonald et al. (2015) used 2012 National Agriculture Imagery Program (NAIP) imagery to systematically survey 8,790 3.2-km x 3.2-km aerial photographs for prairie dog colonies throughout the range of black-tailed prairie dogs in Wyoming. For each detected colony within a grid cell, they digitized the perimeter to determine the area of each feature. To correct for identification errors, they conducted aerial surveys at 400 features identified as prairie dog colonies from NAIP imagery. Of those 400 features, they subsequently conducted ground surveys at 87 colonies to further assess classification. After adjusting for errors of commission, McDonald et al. (2015) estimated 2,505 active black-tailed prairie dog colonies in Wyoming (90% CI: 2,356 to 2,656), which totaled 216,166 acres (90% CI: 199,776 to 242,419). Of those colonies, 18 (90% CI: 11 to 26) were >1,000 acres and totaled 33,389 acres (90% CI: 20,826 to 52,051) combined. Estimates of number of colonies and total area of colonies was similar

between the statewide census and a reduced sample of 1,722 grid cells, which will allow for a reduced survey effort in subsequent range-wide surveys. Utilizing the methods and results from this survey will allow the Department to better monitor black-tailed prairie dogs throughout the state and compare future results to this baseline to document changes in colony number and size.

LITERATURE CITED

McDonald, L., J. Mitchell, S. Howlin, and C. Goodman. 2015. Range-wide monitoring of black-tailed prairie dogs in the United States: pilot study. Western EcoSystems Technology, Inc., Laramie, Wyoming, USA.

McDonald, L. L., T. R. Stanley, D. L. Otis, D. E. Biggins, P. D. Stevens, J. L. Koprowski, and W. Ballard. 2011. Recommended methods for range-wide monitoring of prairie dogs in the United States. Scientific Investigations Report 2011-5063. US Geological Survey, Reston, Virginia, USA.

United States Fish and Wildlife Service [USFWS]. 2000. Endangered and threatened wildlife and plants; 12-month finding for a petition to list the black-tailed prairie dog as threatened. Federal Register 65:5476-5488.

United States Fish and Wildlife Service [USFWS]. 2009. Endangered and threatened wildlife and plants; 12-month finding for a petition to list the black-tailed prairie dog as threatened or endangered. Federal Register 74:63343-63366.

Van Pelt, W. E. 1999. The black-tailed prairie dog conservation assessment and strategy. Nongame and Endangered Wildlife Program Technical Report 159. Arizona Game and Fish Department, Phoenix, USA.

TECHNICAL COMMITTEES AND WORKING GROUPS

SUMMARY OF THE ANNUAL ACTIVITIES OF THE CENTRAL FLYWAY NONGAME MIGRATORY BIRD TECHNICAL COMMITTEE

STATE OF WYOMING

NONGAME BIRDS: Nongame Migratory Birds

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Jim Dubovsky, US Fish and Wildlife Service
Andrea Orabona, Nongame Bird Biologist

SUMMARY

The Central Flyway Council (CFC) was established in 1951 to represent the 10 states (Montana, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas) and 3 Canadian provinces (Saskatchewan, Alberta, and the Northwest Territories) that occur within the flyway. The function of the CFC is to work with the US Fish and Wildlife Service (USFWS), in conjunction with the councils of the Atlantic and Mississippi Flyways, in the cooperative management of North American migratory game birds. Specific responsibilities include season setting of migratory bird hunting regulations. The CFC, via technical committees, also conducts and contributes to a wide variety of migratory bird research and management programs throughout the United States, Canada, and Mexico.

Considerable technical information is required for the Flyway Councils to accomplish their objectives. Various Technical Committees (TCs) have been established to fulfill this role. The Central Flyway Waterfowl TC and the Pacific Flyway Study Committee were established in 1953 and 1948, respectively. The Central Management Unit TC was formed in 1966 to provide technical input on Mourning Dove management and research issues. In 1967, the scope of this TC was broadened to include species other that doves, and the name was changed to the Central Migratory Shore and Upland Game Bird TC. In 1999, the name was changed to the Central Flyway Webless Game Bird TC, and in 2001, the name was again changed to the Central Flyway Webless Migratory Game Bird TC. The Central Management Unit Mourning Dove TC was established in 2003, and its name was changed to the Central Management Unit Dove TC in 2007 to recognize responsibility for all dove species with regulated hunting seasons. In 2006, the Central Flyway Council established the Central Flyway Nongame Migratory Bird TC to address a growing number of regulatory issues for migratory birds that were not currently

addressed by the other TCs, and to broaden the Flyway Council's focus beyond traditional game bird issues.

It is the intent of the CFC and TCs that the division of responsibilities for avian species follows the definition for game birds as defined in the migratory bird conventions with Canada and Mexico. The Central Flyway Waterfowl TC is responsible for the families Anatidae (i.e., ducks, geese, and swans) and Rallidae (i.e., American Coots). The Central Flyway Webless Migratory Bird TC is responsible for the families Rallidae (i.e., rails, gallinules, and other coots), Gruidae (i.e., cranes), Charadriidae (i.e., plovers and lapwings), Haematopodidae (i.e., oystercatchers), Recurvirostridae (i.e., stilts and avocets), Scolopacidae (i.e., sandpipers, phalaropes, and allies), Corvidae (i.e., jays, crows, and their allies), and Columbidae (i.e., pigeons). The Central Management Unit Mourning Dove TC is responsible for the Columbidae family (i.e., doves only). The Central Flyway Nongame Migratory Bird TC is responsible for all migratory birds, as per the Migratory Bird Treaty Act, not included in the above division of responsibilities. Technical Committee members do recognize, however, that they may need to collaborate on some issues. For example, the webless TC should coordinate with the nongame TC on issues related to shorebirds, rails, and federally threatened or endangered species that are not hunted.

The state, provincial, and territorial representatives to the TCs are usually biologists with considerable training and experience in the field of waterfowl, migratory shore and upland game bird, dove, or migratory nongame bird management and research. The function of the TCs is to serve the CFC, with primary responsibility for the technical information needs of the Flyway Council related to management of migratory game birds, wetland resources, and nongame migratory birds. The TCs may also recommend research projects, surveys, and management programs to the Flyway Council for their collective consideration or implementation. The Wyoming Game and Fish Department's Nongame Bird Biologist serves as the state's representatives on the Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC). A list of all current and ex-officio members of the CFNMBTC is presented in Table 1.

Since the its inception, the CFNMBTC has submitted 13 recommendations to the CFC for signing and submission, and 37 letters of correspondence to a variety of recipients on a diversity of nongame issues, both regulatory and non-regulatory. A summary of the recommendations and correspondence is presented below in Tables 2 and 3, respectively.

Table 1. Members of the Central Flyway Nongame Migratory Bird Technical Committee.

State, Province, Agency	Name	Representing
CO	David Klute	Colorado Parks and Wildlife
CO	Liza Rossi (in transition)	Colorado Parks and Wildlife
KS	Rich Schultheis	Kansas Department of Wildlife, Parks, and Tourism
MT	Allison Begley	Montana Fish, Wildlife, and Parks
ND	Sandy Johnson	North Dakota Game and Fish Department
NE	Joel Jorgensen	Nebraska Game and Parks Commission
NM	Peggy Darr	New Mexico Department of Game and Fish
OK	Mark Howery	Oklahoma Department of Wildlife Conservation
SD	Eileen Dowd-Stukel	South Dakota Department of Game, Fish, and Parks
TX	Clifford Shackelford	Texas Parks and Wildlife Department
WY	Andrea Orabona	Wyoming Game and Fish Department
AB	Jason Caswell	Alberta Environment and Parks
NT	Suzanne Carriere	Northwest Territories Department of Environment and Natural Resources
SK	Katherine Conkin	Saskatchewan Ministry of Environment
CWS*	Samantha Song	Canadian Wildlife Service
USFWS*	Jim Dubovsky	United States Fish and Wildlife Service
USFWS*	Dave Kreuper	United States Fish and Wildlife Service
USFWS*	Kammie Kruse	United States Fish and Wildlife Service
USFWS*	Scott Somershoe	United States Fish and Wildlife Service

* Ex-officio members

Table 2. Summary of recommendations submitted by the Central Flyway Nongame Migratory Bird Technical Committee since 2007. Atlantic Flyway (AF); Central Flyway (CF); Central Flyway Council (CFC); Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC); Mississippi Flyway (MF); Technical Committee (TC).

Date	Recommendation #	Pertaining to	Recommendation
March 20, 2007	10	Selection of shorebird species for Avian Influenza surveillance.	The CFC recommends that the USFWS prohibit lethal collection of certain shorebird species during avian influenza surveillance activities. Samples from highly imperiled species should be taken by nonlethal means.
March 20, 2007	11	Comment period during proposed rule stage.	The CFC recommends that the USFWS allows for comment periods for all nongame migratory bird regulations to be 90 days, but no less than 60 days, and considers the option of establishing nongame migratory bird regulatory cycles similar to that which exists for the Waterfowl, Webless, and Central Management Unit-Dove TCs.
March 20, 2007	12	Finalization of MOU for the Cooperative Exchange, Interpretation, and Evaluation of Data and Information Used for Developing Migratory Bird Regulations.	The CFC recommends that the MOU listed above be finalized and signed by the Director of the USFWS and the Chairperson of the CFC.
March 17, 2009	14	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends an equitable distribution of 36 1st year migrant Peregrine Falcon take permits among the CF, MF, AF, for the 20 September to 20 October 2009 trapping season; 12 permits each for the CF, MF, and AF. Of the Central Flyway's allocation, the CFC recommends 10 1st year migrant peregrine falcons for Texas and 2 1st year migrant Peregrine Falcons for Oklahoma for the 20 September to 20 October 2009 trapping season only.

Table 2. Continued.

Date	Recommendation #	Pertaining to	Recommendation
March 17, 2009	15	Allocation of permits for the nestling/post-fledgling 1st year take of Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends allocating 5 nestling/post-fledgling 1st year Peregrine Falcons to Montana, 5 to Wyoming, 4 to Colorado, and 2 to New Mexico for take during the nesting period through 31 August 2009 only.
March 23, 2010	14	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends that 12 of the 36 1st year migrant Peregrine Falcon take permits be allocated to the CF for the fall of the 2010 trapping season, with 11 of the 12 permits designated for Texas and 1 of the 12 permits designated for Oklahoma for the fall 2010 trapping season only.
March 15, 2011	14	Participation in the USFWS Eagle Technical Assessment Team.	The CFC recommends that a Central Flyway Nongame Migratory Bird TC representative is included on the USFWS's Eagle Technical Assessment Team.
March 15, 2011	15	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends adoption of Alternative A (allocation of 12-12-12) for allocation of permits for the take of passage immature Peregrine Falcons for falconry, and that states consider the use of a quota system to provide additional opportunity where the probability of take is expected to be less than 1 permit:1 falcon captured.
March 15, 2012	16	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends a continuation of the alternative outlined above (Recommendation #15).

Table 2. Continued.

Date	Recommendation #	Pertaining to	Recommendation
July 25, 2013	12	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends a continuation of the equal distribution of the 36 passage Peregrine Falcon permits between 3 flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.
July 24, 2014	8	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends a continuation of the equal distribution of the 36 passage Peregrine Falcon permits between 3 flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.
March 4, 2015	12	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends a continuation of the equal distribution of the 36 passage Peregrine Falcon permits between 3 flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.
March 15, 2016	6	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends a continuation of the equal distribution of the 36 passage Peregrine Falcon permits between 3 flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.

Table 3. Summary of correspondence submitted by the Central Flyway Nongame Migratory Bird Technical Committee since 2006. Central Flyway (CF); Central Flyway Council (CFC); Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC), Technical Committee (TC).

Date	Recipient	Issue(s)	CF Key Remark(s)
June 9, 2006 -and- June 12, 2006	Michelle Morgan, Chief, Branch of Recovery and Delisting, USFWS, -and- Brian Millsap, Chief, Division of Migratory Bird Management, USFWS	• Proposed Rule to delist the Bald Eagle • Definition of "disturb" • Review of Draft National Bald Eagle Management Guidelines	• Support the delisting, but "recommend the post-delisting monitoring plan be finalized to coincide with the final delisting". • Definition too narrowly focused on nest sites; "recommend that the term "nest abandonment" be replaced with "nest site or communal roost abandonment". • "Recommend that voluntary habitat protection and management activities be maintained and enhanced in the Guidelines, and that a positive, voluntary, non-regulatory tone be maintained"; represent the most liberal estimates of acceptable disturbance; and "recommend the guidelines be reviewed after 5 years for efficiency and accuracy".
November 3, 2006	Paul Schmidt, USFWS, -and- Dr. Bea Van Horne, USFS	• Review of "Opportunities for Improving North American Avian Monitoring"	• Support the four goals proposed, but believe the report needs to provide more recognition of the realities of personnel, budgets, and time restraints to reach these goals.
November 15, 2006	Robert Blohm, Acting Chief, Division of Migratory Bird Management, USFWS	• Draft EA on Take of Raptors from the Wild under the Falconry Regulations and the Raptor Propagation Regulations	• "Substantially more detail is required regarding the population model, reporting and data management, oversight and communication, and enforcement." • "Concerned that other proposed changes to the regulations governing falconry have not been adequately addressed to-date."

Table 3. Continued.

Date	Recipient	Issue(s)	CFNMBTC Key Remark(s)
January 11, 2007	Robert Blohm, Acting Chief, Division of Migratory Bird Management, USFWS	• Reopening of comment period: Protection of Bald Eagles; Definition of ‘‘Disturb’’	• Reinforced our June 9th and 12th 2006 comments. • Suggested this definition, with our additions in italics: “Disturb means to agitate or bother a bald or golden eagle to the degree that causes *or is likely or predicted to cause* (i) *repeated displacement*, injury, or death to an eagle (including chicks and eggs) due to interference with breeding, feeding, or sheltering behavior, or (ii) nest *site or communal roost* abandonment or *likely or predictable abandonment of nest site or communal roost*.”
March 6, 2007	Central Flyway Council	• Participation of Canadian provinces in CFNMBTC activities	• “Our Committee suggests that an invitation be extended to Northwest Territories, Alberta, and Saskatchewan to nominate an individual to serve on the Central Flyway Nongame Migratory Bird TC for input on issues that affect bird species or populations that are common to provinces and states within the CF.”
March 6, 2007	Dr. Thomas DeLiberto, USDA APHIS-Wildlife Services, -and- Dr. Thomas J. Roffe, USFWS	• Avian influenza surveillance in 2007	• Samples from Buff-breasted Sandpiper and other highly imperiled species should be taken by nonlethal methods.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
August 31, 2007	Jody Millar, Bald Eagle Monitoring Coordinator, USFWS	• Draft Post-delisting Monitoring Plan for Bald Eagles	• The plan is generally well developed, but "we are disappointed that the sampling plan was not completed, approved, and ready for implementation prior to delisting of the Bald Eagle". • "Troubled at the apparent lack of dedicated funding to support the monitoring effort." • Unclear as to what exactly is expected of the states.
August 31, 2007	Division of Migratory Bird Management, USFWS	• Proposed Rule: Authorizations Under the Bald and Golden Eagle Protection Act for Take of Eagles	• Recommend the Service "include state agency expertise in defining regions that may be used to assess the impact of take". • "It has been our understanding that take permits will not be issued and take resulting from disturbance of Bald Eagles will not be prosecuted as long as the national guidelines have been followed." • "Take should be based on state guidelines when they differ from federal guidelines." • Lacks specific information relating to Golden Eagles. Recommend a document similar to Bald Eagle Management Guidelines be developed for Golden Eagles. • Recommend the Service consider development of monitoring strategy for Golden Eagles. Lacking "defensible information on the status and trends of Golden Eagle populations".

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
January 21, 2008	Robert Blohm, Chief, Division of Migratory Bird Management, USFWS	• Draft Environmental Assessment and Management Plan for the take of migrant Peregrine Falcons in the US for use in falconry	• The DEA asserts that Canadian provinces will be involved in the allocation through the Flyways; however, the Canadian Provinces have not accepted our offer to provide representation on the Central Flyway Nongame Migratory Bird TC.
August 14, 2008	H. Dale Hall, Director USFWS	• Eagle Take Permit comment period	• Extend comment period from 30 to 60 days.
September 15, 2008	Diana Whittington, Division of Policy and Directives Management, USFWS	• Draft Environmental Assessment for the Proposal to Permit Take Provided Under the Bald and Golden Eagle Protection Act	• "Based on this review, the CFC does not support any of the proposed alternatives in the Draft Environmental Assessment." • "We request that Golden Eagles be removed from consideration for take permits until such time that sufficient supporting information can be collected and presented. We also recommend that the Service develop an Alternative 4 in the Draft Environmental Assessment to address a proposed take permitting system that includes Bald Eagles only." • "We continue to be concerned at the very short public comment periods provided by the Service for significant issues."
October 1, 2008	Alan Peoples (OK)	• Participation of Oklahoma in CFNMBTC activities	• Request they identify a representative ASAP, or contact the current Council chair if and when they decide to do so.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
March 6, 2009	George Allen Division of Policy and Directives Management	• Proposed Rule for Removal of Rusty Blackbird and Tamaulipas (Mexican) Crow From the Depredation Order and other changes	• We do not believe Rusty Blackbird is a nuisance species warranting depredation measures. Agree to remove it from the depredation order. • Agree to remove the Tamaulipas Crow from the order.
March 9, 2009	Central Flyway Council	• Allocation of nestling/post-fledgling first-year Peregrine Falcons between the Central and Pacific Flyways	• Nongame Technical Committee members of the Central Flyway whose state is split with the Pacific Flyway provided recommendations on the level at which take should be authorized.
March 15, 2010	CFNMBTC	• Developed a flyway-wide list of Species of Greatest Conservation Need	• Illustrated the diversity of the species with which we work and demonstrated the Central Flyway Nongame Migratory Bird TC's interest in all native habitat types.
March 23, 2010	US Senators Feinstein and Alexander, -and- US Representatives Dicks and Simpson	• State Wildlife Grants program appropriation	• Requests funding for the State Wildlife Grants program at a level of $90 million during FY2011 and retention of the 65:35 cost-share ratio, which Congress enacted during FY2010.
March 23, 2010	George Allen, Chief Branch of Permits and Regulations, USFWS	• Bird Banding Lab letter	• The CFC requested that each of the four flyways be allowed a 120-day review period in order to evaluate and prepare a coordinated response among our TC.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
March 4, 2011 (original) August 10, 2011 (signed)	USFWS	• Double-crested Cormorant letter	• The CFC had several questions about the USFWS's long-term vision to manage Double-crested Cormorants before we develop a flyway management plan.
March 23, 2011	USFWS	• Eagle Technical Assessment letter	• We requested the USFWS to include the CFNMBTC in inaugural and on-going efforts to address Bald and Golden Eagle issues.
October 3, 2011	USFWS	• Bald and Golden Eagle captive propagation letter	• In general, we do not see the need and, therefore, do not support captive propagation of Bald and Golden Eagles.
October 3, 2011	Senators Reed and Murkowski, and Representatives Simpson and Moran	• State Wildlife Grants support letter	• Support the continuation of State Wildlife Grants funding at $90 million for FY2012 and retention of the 65:35 cost-share ratio.
December 20, 2011	USFWS	• Double-crested Cormorant management	• Request 60-day comment period extension for Federal Register Notice of Intent regarding Double-crested Cormorant management.
March 13, 2012	USFWS	• Double-crested Cormorant management	• Comments to Federal Register Notice of Intent regarding Double-crested Cormorant management.
October 5, 2014	George Allen, USFWS	• Blackbird depredation	• Informal comments regarding a Pre-publication Draft Proposed Rule Regarding Amendments to the Migratory Bird Treaty Act.
October 9, 2012	Central Flyway Webless and Waterfowl Technical Committees	• Technical Committees' species responsibility	• Request for dialogue to improve how the different TCs address issues related to species based current Flyway structure. Non-hunted species currently fall under the responsibility of the TCs that traditionally focus on game species.
January 29, 2013	Central Flyway Council	• 2013 meeting schedule	• Inform Council of the CFNMBTC plan to meet in July rather than March.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
April 8, 2013	George Allen, USFWS	• Raptor rehabilitation and falconry regulations	• Courtesy response expressing gratitude for the opportunity to comment on pre-publication draft Proposed Rule regarding revisions to rehabilitation and falconry regulations.
November 26, 2013	USFWS	• Proposed rule to list the *rufa* Red Knot as a threatened species	• USFWS needs to evaluate the Red Knot's life history and migration strategy, and identify a network of key Red Knot habitats or sites. • Geographic range should only include areas where the Red Knot occurs regularly (annually or near annually). • USFWS needs to evaluate different populations of the *rufa* Red Knot as Distinct Population Segments.
March 31, 2014	USFWS	• Draft Environmental Assessment management of Double-crested Cormorants	• Need a more thorough editorial review. • Double-crested Cormorant population size needs to be revised using the best available information.
July 22, 2014 (email sent)	Dave Morrison (TX)	• Double-crested Cormorant management	• Management Plan that the CFNMBTC compiled, as requested by the CFC.
March 6, 2015	Central Flyway Council	• Southern Wings Program	• Increased awareness of the Southern Wings Program, and support from the CFNMBTC.
March 6, 2015	Central Flyway Council	• CFNMBTC activities	• A brief update to the CFC on CFNMBTC activities to-date. Included correspondence and recommendations logs.
March 10, 2015	Dan Ashe, USFWS	• Results of stable isotope analysis of Peregrine Falcon feathers	• Request for analysis to be completed so that the next steps for passage Peregrine Falcon harvest may be considered.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
July 23, 2015	Central Flyway Council	• CFNMBTC activities	• A brief presentation to the CFC on CFNMBTC activities to-date. Included general activities, 2012 NTC review, CFNMBTC thoughts, CFNMBTC recent activities, and MBTA Take Notice of Intent.
July 24, 2015	USFWS	• PEIS for evaluating the potential to authorize incidental take of migratory birds under the MBTA	• Comments were provided on 13 of the 15 various points of consideration, as well as in the "other comments" section.
February 24, 2016	Scott McNuff	• Comments on increasing the take quota for Peregrine Falcons	• CFNMBTC will review the newly released "Population Estimates for Northern Juvenile Peregrine Falcons with Implications for Harvest Levels in North America". • Requested a final isotope analysis report from USFWS prior to the annual CFNMBTC meeting in September 2016. • Will recommend to the CFC to continue the same level of take.
February 24, 2016	Brian Millsap	• Peregrine Falcon isotope analysis	• Formal request from the CFNMBTC for a complete isotope analysis report prior to the September 2016 CFNMBTC meeting.

WYOMING BIRD RECORDS COMMITTEE

STATE OF WYOMING

NONGAME BIRDS: Rare and Unusual Birds

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Bureau of Land Management Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2014 – 31 December 2015

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Courtney Rudd, Nongame Biologist

SUMMARY

The Wyoming Bird Records Committee (WBRC) was established by the Wyoming Game and Fish Department (Department) Nongame Program in 1989 to accomplish the following goals:

1) To solicit, organize, and maintain records, documentation, photographs, audio recordings, and any other material relative to the birds of Wyoming.
2) To review records of new or rare species or species difficult to identify and offer an intelligent, unbiased opinion of the validity or thoroughness of these reports. From these reviews, the WBRC will develop and maintain an Official State List of Birds in Wyoming.
3) To disseminate useful and pertinent material concerning the field identification of Wyoming birds in order to assist Wyoming birders and ornithologists with increasing their knowledge and skill.

The WBRC is interested in promoting and maintaining quality and integrity in the reporting of Wyoming bird observations, and it treats all bird records as significant historical documents. The WBRC operates under a set of bylaws approved in 1991 and updated in 1992, 1998, and 2015.

As of 31 December 2015, the WBRC has reviewed 1,387 reports of rare and unusual birds in Wyoming. A total of 1,135 (82%) have been accepted and 252 (18%) have not been accepted. Nine reports have been submitted thus far in 2016 and are awaiting review.

The WBRC Database is a dynamic document, updated once or twice a year following the WBRC meetings. A full report of all sightings submitted to the WBRC through 2015, species for which the WBRC requests documentation, rare and unusual bird sighting forms, information on

how to document rare and unusual birds, and the WBRC bylaws are available from the Nongame Bird Biologist in the Department's Lander Regional Office or on the Department's website: https://wgfd.wyo.gov/Wildlife-in-Wyoming/More-Wildlife/Nongame-Birds.

ACKNOWLEDGEMENTS

Funding was provided by the Wyoming State Legislature General Fund Appropriations and through a Cooperative Agreement with the Bureau of Land Management, for which we are extremely grateful. We wish to thank all observers for taking the time to submit their sightings to the WBRC. We are also indebted to the following Wyoming Bird Records Committee members for their invaluable efforts: B. Hargis, G. Johnson, J. Maley, C. Michelson, and S. Patla.

WYOMING BAT WORKING GROUP ANNUAL SUMMARY

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: Unites States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations
Wyoming Wildlife – The Foundation

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2015 – 14 April 2016

PREPARED BY: Nichole Bjornlie, Nongame Mammal Biologist

SUMMARY

The Wyoming Bat Working Group (WYBWG) is a subgroup of the larger Western Bat Working Group, which coordinates management and conservation of bats in the western US. Both groups were formed in the mid-1990s to address growing concern over Townsend's big-eared bat (*Corynorhinus townsendii*; COTO). After the development of the COTO Conservation Assessment and Strategy (Pierson et al. 1999), emphasis broadened to include all bat species. The WYBWG is comprised of representatives from several federal and state agencies, local conservation districts, and non-governmental organizations.

The WYBWG has focused considerable resources on addressing potential threats to populations of bats in Wyoming. Perhaps the largest concern for bats in the US currently is white-nose syndrome (WNS). Severe declines in abundance have been reported at many hibernacula in the eastern US. Notably, the implications for populations in the West are unknown, and a coordinated management response was lacking for Wyoming. Consequently, in 2010, the WYBWG drafted a strategic plan to guide and coordinate management response to this potential threat in Wyoming (Abel and Grenier 2010). The plan provides guidance on addressing the threat of WNS and standardizes management actions to facilitate detection of the fungus. The WYBWG and Wyoming Game and Fish Department (Department) continue to implement strategies in the state WNS strategic plan and are in the process of updating this plan in light of new research and protocols. In addition, partners within the WYBWG continue to coordinate on cave and mine surveys to locate and monitor hibernacula. These surveys contribute to routine population monitoring and help address closure needs for both bat and human safety.

Beginning in 2016, the WYBWG will implement the North American Bat Monitoring Program (Loeb et al. 2015; NABat) at sites throughout Wyoming. This program, similar to the Breeding Bird Survey for avian species, is a North America-wide effort to conduct annual monitoring of bats, including hibernacula and maternity counts and acoustic surveys. Through the Department, the WYBWG will coordinate on surveys to ensure state- and agency-level needs are addressed; the Wyoming Natural Diversity Database is looking into the potential for data storage that would allow all partners access to data collected through NABat surveys.

LITERATURE CITED

Abel, B., and M. Grenier. 2011. A strategic plan for white-nose syndrome in Wyoming. Wyoming Game and Fish Department, Lander, USA.

Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, J. D. Reichard, K. M. Irvine, T. E. Ingersoll, J. T. H. Coleman, W. E. Thogmartin, J. R. Sauer, C. M. Francis, M. L. Bayless, T. R. Stanley, and D. H. Johnson. 2015. A plan for the North American Bat Monitoring Program (NABat). US Department of Agriculture Forest Service, General Technical Report SRS-208. Southern Research Station, Asheville, North Carolina, USA.

Pierson, E. D., M. C. Wackenhut, J. S. Altenbach, P. Bradley, P. Call, D. L., Genter, C. E. Harris, B. L. Keller, B. Lengus, B. Luce, K. W. Navo, J. M. Perkins, S. Smith, and L. Welch. 1999. Species conservation assessment and strategy for Townsend's big-eared bat (*Corynorhinus townsendii* and *Corynorhinus townsendii pallescens*). Idaho Conservation Effort, Idaho Department of Fish and Game, Boise, USA.

APPENDIX I – OTHER REPORTS
(NOTE: SOME OF THESE REPORTS HAVE NOT BEEN EDITED, AND APPEAR HERE AS THEY WERE SUBMITTED TO THE NONGAME PROGRAM)

WYOMING COMMON LOON (*GAVIA IMMER*)
SUMMARY REPORT 2015

SUBMITTED TO:

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3/23/2016

The mission of Biodiversity Research Institute is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific findings to advance environmental awareness and inform decision makers.

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PROJECT FUNDING

Initial funding for this project was provided by the National Park Service in 2012 and 2013, as well as a grant from the Wyoming Governor's Big Game License Coalition in 2013. Continued funding for this project has been generously provided by the Ricketts Conservation Foundation, which was formed to support the conservation of wildlife and natural resources.

SUGGESTED CITATION:

Spagnuolo, V. A., A. J. Byrd, J. Fair, C. W. Brown, C. Persico, G. Stout, M. R. Kneeland, and D. C. Evers. 2016. Wyoming Common Loon (*Gavia immer*) Summary Report 2015. Report # 2016-07. Biodiversity Research Institute, Gorham, Maine.

GIS CREDIT:

All maps were produced by Jeff Tash of Biodiversity Research Institute.

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1.0 EXECUTIVE SUMMARY

Supported by a grant from the Ricketts Conservation Foundation, the Biodiversity Research Institute (BRI) has undertaken a continent-wide conservation study (Restore the Call) in support of the recolonization of former breeding range for the Common Loon (*Gavia immer*), a key indicator of aquatic integrity for lakes and near shore marine ecosystems across North America. As part of this study, BRI has begun a comprehensive study of the northwestern (NW) Wyoming loon population, an island population disconnected by over 200 miles from populations to the north, in collaboration with the Wyoming Game and Fish Department, Yellowstone National Park, Caribou-Targhee National Forest, Bridger-Teton National Forest, and Grand Teton National Park. These agencies have surveyed the presence of adults and large chicks since the late 1980s. Following an observed high of 21 territorial pairs, a decline in the number of pairs was detected starting in 2007. In the NW Wyoming study area, loon presence and reproductive success were monitored throughout the breeding seasons 2013-2015 by shoreline, boat, and aerial surveys. In 2015, the number of observed territorial pairs increased to 17 pairs from 16 pairs in 2014 and 13 pairs in 2012 in the study area. Productivity in 2015 declined compared to the high levels observed from 2012 – 2014, but at 0.53 chicks surviving per territorial pair (CS/TP) productivity remained above the 0.48 threshold needed for population stability. Eight loons were captured and banded using both diurnal and nocturnal capture methods. A geolocator was recovered from the Wolf Lake female and its data showed that the loon wintered off the southern end of the Baja Peninsula. The Cygnet Lake female died as a result of bycatch from lake trout gillnetting on Yellowstone Lake. This marked the first official documentation of a Wyoming loon dying as a result of gillnetting on Yellowstone Lake. An extensive survey effort was conducted in the Wind River Range resulting in the observation of unpaired resident loons. While inconsistent monitoring in YNP during and after the 2007 decline makes forecasting population changes in this population difficult, the current number of pairs, the presence of resident unpaired adults, and productivity above 0.48 CS/TP in 6 of the last 7 years suggests the potential for future additional territorial pairs.

2.0 INTRODUCTION

The Common Loon (*Gavia immer*) is a highly charismatic and iconic species of North America that has come to symbolize wild areas. Loons have been able to acclimate to human disturbance in portions of their breeding range, but generally active management and outreach actions are needed to offset adverse human impacts in areas of their southern breeding range. In the western United States, loons historically nested as far south as northern California, southern Idaho, and western Wyoming, but the southern boundary of their distribution was driven northward by human influences (Evers 2007). At the end of the 2014 breeding season, about 109 territorial pairs were known in the western United States. Most of these breeding pairs were located in Montana (75 pairs, 69%), while Washington, Wyoming, and Idaho supported 17-18 (16%), 16 (15%), and 0 (0.0%) territorial pairs, respectively.

The Wyoming State Wildlife Action Plan (SWAP) lists the Common Loon as a Tier I Species of Greatest Conservation Need. Common Loons exhibit a "K-selected" life history pattern (i.e., long-lived, low annual fecundity, low annual adult mortality rate), so significant changes in their breeding population are symptomatic of chronic stressors (Evers 2007, Evers et al. 2010). Therefore, this species is viewed as a biologically valuable indicator of aquatic integrity (Evers 2006). The Wyoming population consists of loons in Yellowstone National Park (YNP), the Caribou-Targhee National Forest (CTNF), Grand Teton National Park (GTNP), and the Bridger-Teton National Forest (BTNF). Annual monitoring efforts at many lakes in the NW Wyoming region by WGFD and YNP have documented the number of adults and large chicks since the late 1980s, and beginning in 2007 their results indicated a decline in the number of territorial pairs in NW Wyoming (Evers et al. 2013, Spagnuolo et al. 2014).

In 2013, Biodiversity Research Institute (BRI) completed the first comprehensive loon monitoring effort throughout NW Wyoming. These efforts confirmed that the number of surveyed territorial pairs declined from a historic count of 21 pairs starting in 2006. The steepness and extent of the decline is uncertain due to inconsistent monitoring in YNP, but survey efforts reported 15 pairs in 2007 and BRI's efforts identified 14 pairs in 2013. An increase to 16 territorial pairs, as well as high productivity, was observed in 2014. In 2015, BRI continued its efforts to monitor the Wyoming loon population and identify and mitigate anthropogenic threats and stressors.

2.1 PROJECT FUNDING

This project was initiated in 2012 and 2013 through funding from the National Park Service and the Wyoming Governor's Big Game License Coalition. Through a grant from the Ricketts Conservation Foundation (RCF) for a national scale loon study, BRI biologists, working with state and federal collaborators, are addressing three major conservation components in Wyoming and other parts of the Common Loon's range over a 5-year period (2013 – 2017): 1) population assessments through surveys and habitat evaluations; 2) creating specialized outreach and conservation initiatives; 3) compiling comprehensive nationwide loon health assessments; and, 4) identifying research needs and restoration options, including the potential translocation of chicks.

2.2 COMMON LOON BREEDING HABITAT REQUIREMENTS

Although Common Loons in eastern and mid-western populations generally prefer lakes >60 acres (>24 ha) with clear water, an abundance of small fish, numerous small islands, and an irregular shoreline that creates coves, they can be found in a wide variety of freshwater aquatic habitats. Lake size and configuration are important determinants for loon density in a region. Loon habitat use patterns generally follow that of Pulliam and Danielson's (1991) ideal pre-emptive distribution model, where an individual selects the best available territory and prevents other individuals from occupying that site.

Water clarity is an important lake characteristic for breeding loon success. Loons are visual underwater predators and clear water is crucial for foraging efficiency. A Michigan study documented that the time adult loons spent foraging in turbid water was significantly greater than in clear water (Gostomski and Evers 2001). Secchi Disk readings of 5 feet (1.5 m) or less alter loon foraging behavior (Barr 1986). Loons prefer foraging in clear waters of littoral zones and tend to avoid deeper parts of large lakes. Preferred prey species that are 4 to 6 inches (10 to 15 cm), such as yellow perch (*Perca flavescens*) in the mid-west and northeast US, are found in this zone (Barr 1996).

Nesting ecology of the Common Loon has been extensively studied in the northeast and mid-west. Loons nest in close proximity to the water's edge and tend to select small islands, floating bog mats, and marshy hummocks as nest sites. Loons prefer to nest on small islands, primarily the lee side (Olson and Marshall 1952, Sutcliffe 1980, Titus and Van Druff 1981, Yonge 1981, Dahmer 1986, Jung 1987). Floating bog mats afford particularly high nesting success (Reiser 1988) because they can move with water level fluctuations related to natural and anthropogenic influences. Marsh and mainland sites are of lower preference and most likely occur in response to lack of islands, shoreline development (Alvo 1981, Christenson 1981, McIntyre 1988), and high conspecific densities.

Nest sites are generally located within 4 feet (1.2 m) of the water's edge, and available submergent and emergent materials are often used to build a bowl-shaped nest structure. Common Loons often select nest sites with steep drop-offs that allow for underwater approaches and exits (Olson and Marshall 1952, Christenson 1981, McIntyre 1988, Ruggles 1994); however, Sutcliffe (1980) and Valley (1987) did not find this to be a predictor of site location. Strong et al. (1987) found between-year reuse of nest sites by loons to be 78-88%. Changes in nest locations were more frequent after nest failures and reuse occurred more often after successful nesting.

Chick rearing areas share much of the same attributes as foraging areas. They are typically in shallow water close to shore, with prey size classes suitable for feeding young. These areas experience less prevailing wind and waves that could otherwise separate chicks from adults. Chicks hide among shoreline vegetation in response to threats or when left unattended (Yonge 1981, Strong and Bissonette 1989, Ruggles 1994).

2.3 COMMON LOON POPULATION DYNAMICS AND DISPERSAL

Common Loon populations have been well studied across North America, particularly in the northeast and mid-west. Using long-term datasets from across different populations, Evers (2007) and Mitro et al. (2008) reported that in order for a Common Loon population to remain stable, a territorial pair needs to fledge about one chick every other year (0.48 chicks surviving per territorial pair – CS/TP). Even with long-term reproductive success above 0.48 CS/TP, loons are poor colonizers of unoccupied habitat. Dispersal of individuals is limited and, therefore, loons are slow in re-colonizing new areas. Young loons returning to freshwater lakes after maturing on the ocean show an average dispersal of 8 miles (13 km) from their natal lakes; however, dispersal upwards of 57 miles (92 km) has been documented (Evers et al. 2000). Intra-season movements of adults on the breeding grounds are much more limited, with an average of 2.5 miles (4 km) and few records of dispersal beyond 12 miles (20 km; Evers 2001). Females are much more likely to disperse farther than males, and new territories are more likely to be established near former territories. Across North America, both sexes exhibit a high degree of territory fidelity, with 80% of males and 82% of females returning to the same lake or territory in successive years (Evers 2007).

3.0 PROJECT GOALS AND OBJECTIVES

The goals of the Wyoming Loon Project as part of Restore the Call are: 1) Identify the distribution of territorial pairs of Common Loons in NW Wyoming; 2) Identify and mitigate anthropogenic threats to the Wyoming loon population; 3) Enact measures to restore, strengthen, and expand the Wyoming loon population; and 4) Improve understanding of Wyoming Common Loon natural history and conservation status.

The objectives for 2015 were to: 1) Monitor existing loon territories and reproductive success measured as CS/TP and identify new loon pairs and unpaired adults in the study area; 2) Capture and color mark individual loons for demographic and movement research and obtain blood and tissue samples for comprehensive health evaluation in BTNF, CTNF, and YNP; 3) Deploy additional geolocators and recover previously deployed geolocators for migration and wintering location data; 4) Deploy cameras at nest sites to investigate nesting biology threats, and causes of nest failure; and 5) Expand survey efforts on Yellowstone Lake, Jackson Lake, and in the Wind River Range.

4.0 STUDY AREA

The study was conducted in the NW portion of Wyoming, which includes a large portion of the Greater Yellowstone Ecosystem. This study area included most lakes within YNP, GTNP, and parts of the CTNF and BTNF. The landscape is characterized at higher elevations by lodgepole pine (*Pinus contorta*) and mixed conifer forests and alpine meadows, with sagebrush steppe and grasslands occurring at lower elevations. Many lakes in the region exist between altitudes of 6,000 and 8,000 feet (1,829 and 2,438 m), the largest of which are Yellowstone Lake and Jackson Lake. NW Wyoming is a major vacation destination in North America, with YNP alone drawing more than 3 million visitors annually, the majority of which occurs in the summer months.

5.0 METHODS

5.1 DETERMINING SURVEY LAKES

Lakes with known loon presence in 2012 and 2013 were the primary focus of our surveys and were visited as early as travel, phenological conditions, and logistics allowed. Secondarily, historically occupied lakes were surveyed to confirm continued absence or recolonization. Lastly, surveys were conducted on lakes in the region appearing to have characteristics of Common Loon use, but which were not known to have historical loon presence. Identifying lakes not currently occupied facilitates tracking of possible future population expansion.

5.2 GROUND AND AERIAL SURVEYS

Survey methods were consistent with those developed by the Loon Preservation Committee (Loon Preservation Committee 2004). Lakes were often surveyed from shore. Canoes or kayaks were used, if feasible, and when an island nest site required access. Yellowstone Lake was surveyed from shore, canoe, and motorboat, as well as aerially. All lakes were surveyed using 10X binoculars and a 15-45X spotting scope. Information on breeding loons was obtained from the greatest distance possible to minimize impacts on nesting and brooding activities. Nests were examined after chicks hatched and the family left the nest area, or after nest failure. Aerial surveys from a Piper Super Cub or American Champion Scout flown at low altitudes were conducted throughout the season to verify loon presence and reproduction, and to survey inaccessible lakes due to bear management area restrictions, snow conditions, or general remoteness.

Lakes with active nesting pairs in 2015, or nesting in previous years, were searched for nest sites. For each nest found, the location (island, marsh, or shoreline) and nest type (bowl, scrape, or hummock) were recorded and photos were taken, if possible. Approximate GPS coordinates of each nest were obtained using a handheld GPS or located on Google Earth.

5.3 DETERMINATION OF PRESENCE AND REPRODUCTIVE SUCCESS

Territorial loon pairs were identified according to observed territorial behavior, such as close physical association, defensive posturing, and vocalizing along territorial borders within a lake. Territories are areas of a lake(s) used by pairs for feeding, resting, breeding, nesting, and chick rearing, and that are protected against incursion by other loons (and sometimes waterfowl) for a minimum of four weeks. Territory types were determined as occupying a single lake (whole lake territory), part of a larger lake (partial lake territory), or more than one lake (multiple lake territory). Territories are used as a unit of reference in describing loon breeding activity.

Nesting pairs were defined by the presence of at least one egg as determined by observed chicks hatched, egg shell fragments post-hatch or failure, presence of abandoned eggs, and eggs observed through a scope when nesting loons rotated egg(s) or during an exchange of incubation duties by pair members. Successful pairs hatched at least one chick. Unsuccessful nesting attempts were categorized as failed if conclusive evidence of nest failure could be determined. Possible causes of nest failure included: avian predation, mammalian predation, water level fluctuations (rise or fall), human disturbance, non-territorial loon disturbance, egg inviability, and unknown (e.g., egg(s) missing with no additional evidence or eggs cold and loon off nest). We define successful nests as those nests where chicks hatched. We define the term chicks surviving as loon young ≥6 weeks post-hatching, which we assumed to successfully fledge (Evers 2007).

5.4 CAPTURE AND BANDING METHODS

Common Loon capture was attempted using diurnal (suspended dive net) and nocturnal (night-lighting) techniques in CTNF, BTNF, and YNP. Diurnal capture involves stretching an underwater mist net between two parallel floating PVC pipes, and using loon decoy(s) and loon vocalizations to lure loons into the netted area. A loon is entangled when it swims underwater into or dives from above into the net. Nocturnal capture is traditionally attempted from a boat or canoe for loon pairs with young chicks, and requires using spotlights and recordings/vocalizations to approach loons close enough for them to be netted with a large dip net.

Each bird was captured, measured, and sampled according to BRI's Protocols for Capture and Banding and Loon Tissue Sampling (BRI unpublished protocols 2014, Evers 1993). Blood was drawn for genetics, stable isotope analysis, and health evaluation. Health analyses included hematology and plasma biochemistry, hemoparasite screen, blood mercury and lead (Pb) analysis, cyanobacteria detection, and infectious disease surveillance. Feathers sampled included the second secondaries, two tail feathers, and three or four scapular feathers. An aluminum USGS band with a federal ID number and a colored band were attached to one leg, and two colored bands were placed on the other in unique sequences for individual identification. In 2015, three adult loons were outfitted with a geolocator (LOTEK Wireless LAT 2000 Series, Model LAT 2900) attached to a color band to determine migration paths and wintering grounds. These devices record sunlight levels over time that can be used to calculate the bird's approximate location (latitude and longitude). The resulting location data's precision is limited to within approximately 124 miles (200 km). Because these devices need to be retrieved to download data, birds that received a geolocator must be re-captured in following years.

6.0 RESULTS

6.1 WYOMING LOON POPULATION OVERVIEW

A total of 17 territorial pairs (TP) were observed across the study area in 2015, 15 of which nested (Table 1). A total of 11 chicks hatched (CH) from these nesting pairs (NP), with 9 of these chicks surviving (CS). Chick survivorship (CS/CH) was high at 0.90. Both the nesting propensity (NP/TP) of 0.88 and hatching success (CH/NP) of 0.73 were high compared to reported averages for other populations in the Northeast and Midwest (Evers 2007). Overall loon productivity (CS/TP) for the region was 0.53. There were six documented nest failures among the following territories: Indian Lake, Lilypad Lake, Lewis Lake, Tanager Lake, Yellowstone Lake Flat Mountain Arm Territory, and Yellowstone Lake Peale Island Territory.

Table 1: Loon monitoring results in the northwestern Wyoming study area, 2015.

2015 Demographics	
Territorial Pairs (TP)	17
Nesting Pairs (NP)	15
Renests	2
Successful Nesting Pairs (SNP)	7
Chicks Hatched (CH)	11
Chicks Surviving (CS)	9
Unpaired Adults	9
Adult Mortalities	2
2015 Demographic Rates	
Nesting Propensity (NP/TP)	0.88
Nest Success (SNP/NP)	0.47
Hatching Success (CH/NP)	0.73
Chick Survivorship (CS/CH)	0.82
Productivity (CS/TP)	0.53
Percent Population Unpaired	0.21

In 2015, 11 territorial pairs were observed in YNP, 5 in CTNF, 1 in BTNF, and 0 in GTNP (Figure 1, Table 2). Loon pairs within YNP provided the majority of productivity, with 44% of the chicks surviving in the study area, while CTNF, BTNF, and GTNP produced 33%, 22%, and 0%, respectively. In addition to these loon pairs, 9 unpaired adults were observed in the study area, constituting 21% of the total adult population. Two adult loon mortalities were documented in NW Wyoming.

Notable changes in the distribution of loons in NW Wyoming for the 2015 breeding season were highlighted in YNP by the return of a pair to Delusion Lake, the loss of pairs on

Shoshone Lake and at South Arm West (Yellowstone Lake), and the documentation of a pair on Ranger Lake for the first time since 2006 (Figure 1, Table 2). No pair occupied Emma Matilda Lake (GTNP) in 2014 – 2015, but a single adult, presumably the remaining pair member from 2013, was observed behaving territorially early in the season. Other territories in the region were stable; however, productivity was limited due to nine nest failures. While human disturbance is suspected to have contributed to some nest failures, including Lewis Lake, Beula Lake, and Flat Mountain Arm on Yellowstone Lake, monitoring efforts were not able to determine the exact causes of the nest failures. Unpaired breeding age adults were widely distributed across the study area in 2015, with unpaired loons observed on Grebe Lake, Yellowstone Lake, Emma Matilda Lake, and new unpaired adult presence along the Grassy Lake Road on Winegar Lake. These loons were observed intruding on existing territories or occupying non-territory lakes/areas, and tended to move between neighboring lakes throughout the summer.

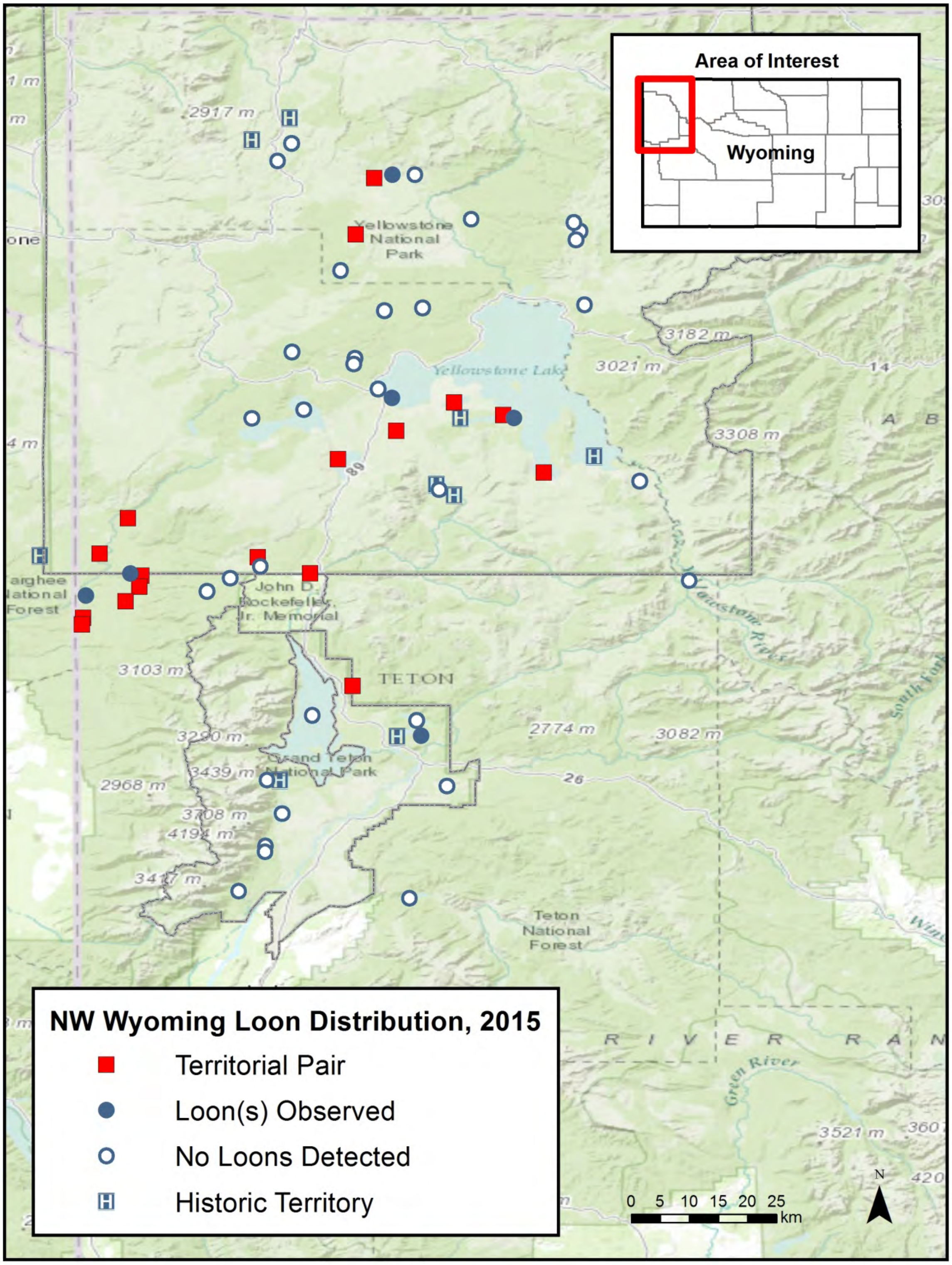

Figure 1: Loon presence and lakes surveyed by BRI in northwestern Wyoming, 2015.

Table 2: Northwestern Wyoming occupancy and reproductive success, 2015. TP = Territorial Pair, NP = Nesting Pair, CH = Chick Hatched, CS = Chick Surviving, UA = Unpaired Adult.

Location	TP	NP	CH	CS	UA
Yellowstone National Park					
Wolf Lake	1	1	1	1	0
Grebe Lake	0	0	0	0	3
Cygnet Lakes	1	1	2	1	0
Shoshone Lake – East/West	0	0	0	0	0
Riddle Lake	1	1	0	0	0
Lewis Lake	1	1	0	0	0
Delusion Lake	1	1	1	0	0
South Delusion Lake	0	0	0	0	0
Heart Lake – East/West	0	0	0	0	0
Tanager Lake	1	1	0	0	0
Beula Lake	1	1	0	0	0
Lilypad Lake	1	1	0	0	0
Ranger Lake	1	1	2	2	0
Yellowstone Lake					
Grant Village Area	0	0	0	0	1
Flat Mountain Arm	1	1	0	0	1
South Arm – Peale Island	1	1	0	0	0
South Arm – West	0	0	0	0	0
South East Arm	0	0	0	0	0
	11	**11**	**6**	**4**	**5**
Caribou-Targhee National					
Bergman Lake	1	1	2	2	0
Indian Lake	1	1	0	0	1
Moose Lake	1	0	0	0	0
Loon Lake	1	1	1	1	0
Winger/Junco/Fish Lakes	1	0	0	0	2
	5	**3**	**3**	**3**	**3**
Bridger-Teton National					
Arizona Lake	1	1	2	2	0
Lower Slide Lake	0	0	0	0	0
	1	**1**	**2**	**2**	**0**
Grand Teton National Park					
Emma Matilda Lake	0	0	0	0	1
Jackson Lake	0	0	0	0	0
Leigh Lake	0	0	0	0	0
	0	**0**	**0**	**0**	**1**
2015 Wyoming Totals	**17**	**15**	**11**	**9**	**9**

6.2 LOON CAPTURE, BANDING, AND MERCURY RESULTS

A total of 5 adult loons and 3 chicks were captured using nocturnal capture methods in Wyoming in 2015 (Table 3). Three adults were captured in YNP, one adult and one chick in CTNF, and one adult and two chicks were captured in BTNF. The Wolf Lake female and the Arizona Lake male were recaptures from previous years. A geolocator deployed in 2014 was recovered from the Wolf Lake female (see Section 6.3). All other adults captured were tagged with geolocators except the Bergman Reservoir female. Mercury levels were assessed in both blood and feathers for all birds captured in 2015(Table 3). Similar to results in previous years, NW Wyoming loon mercury levels were below thresholds for adverse effect levels for both blood (3.0 mg/kg) and feathers (40.0 mg/kg) (Evers et al. 2005, Evers et al. 2008). Wolf Lake, while below these thresholds, continues to have more elevated blood concentrations. Over the past three breeding seasons (2013-2015) a total of 13 adults and 3 chicks have been banded in NW Wyoming.

Table 3: Capture, banding, and mercury data for adult Common Loons caught in northwestern Wyoming, 2015.

Territory	Area	Age	Sex	Weight (g)	Blood Mercury (mg/kg)	Feather Mercury (mg/kg)	Recapture (Y/N)	Geolocator Deployed
2015 Capture and Banding Results								
Wolf Lake	YNP	AD	Female	3250	2.406	-	Y	Recovered
Cygnet Lake	YNP	AD	Female	3130	0.409	5.859	N	X
Flat Mountain Arm	YNP	AD	Female	2950	-	12.934	N	X
Bergman Res.	CTNF	AD	Female	N/A	0.242	4.364	N	
Arizona Lake	BTNF	AD	Male	N/A	1.577	11.980	Y	X
Arizona Lake	BTNF	CH	Unk	1350	0.185	-	N	
Arizona Lake	BTNF	CH	Unk	2350	0.196	-	N	
Loon Lake	CTNF	CH	Unk	1900	-	-	N	
2014 Capture and Banding Results								
Lewis Lake	YNP	AD	Male	3500	1.414	18.117	N	X
Wolf Lake	YNP	AD	Female	3300	2.544	18.276	N	X
Indian Lake	CTNF	AD	Female	3250	0.586	6.542	N	
Indian Lake	CTNF	AD	Male	3950	0.697	6.220	N	
Bergman Res.	CTNF	AD	Male	3800	1.142	9.545	N	
Moose Lake	CTNF	AD	Male	4425	1.388	17.543	N	
Loon Lake	CTNF	AD	Male	4000	0.894	8.260	N	X
Arizona Lake	BTNF	AD	Male	3810	1.759	17.359	N	
2013 Capture and Banding Results								
Arizona Lake	BTNF	AD	Female	2750	1.570	5.526	N	X
Loon Lake	CTNF	AD	Female	3050	1.195	20.265	N	X
Female Weights (*N*=6)				Range	2750 – 3300		Average	3063
Male Weights (*N*=6)				Range	3500 – 4425		Average	3914

6.3 WYOMING LOON WINTER HABITAT

The recapture of the Wolf Lake female and recovery of the geolocator revealed that this bird spent the winter of 2014/2015 around the southern end of the Baja Peninsula (Figure 2). The fall migration path was southward over land across the Colorado Plateau rather than westward to the Oregon or Northern California coast and then south along the Pacific coast. Location data over time suggest that the bird wintered on the west side of the Baja Peninsula for most of October, then spent November and December on the east side of the peninsula. The location data lost accuracy in mid-December, so there are no data on late winter and spring locations or returning migration path.

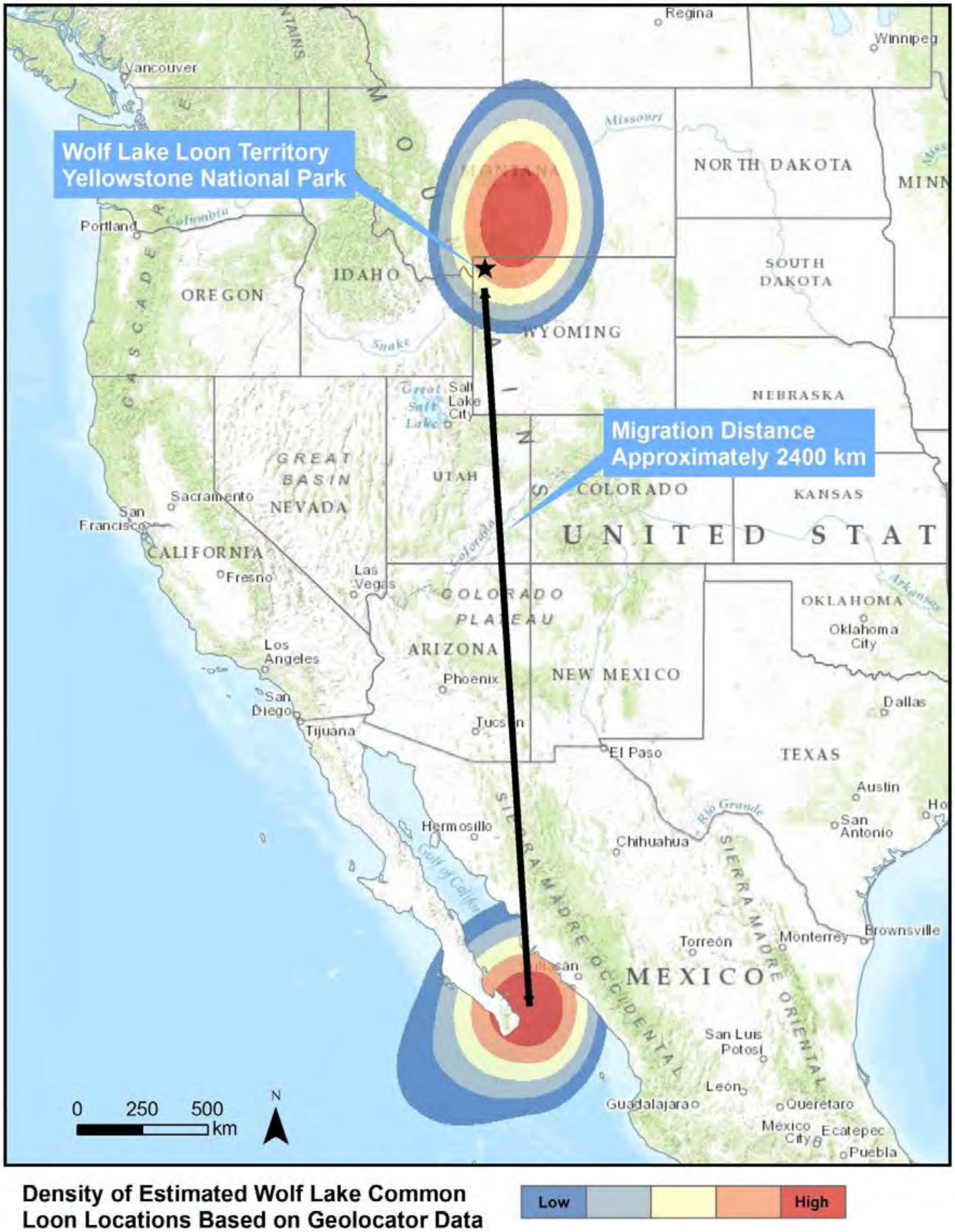

Figure 2: Relative density of the Wolf Lake Common Loon female wintering location based on geolocator data from winter 2014/2015.

While location data for migration and wintering locations are incomplete, the geolocator recorded data through May 2015 on temperature, sea surface temperature (SST), and wet vs. dry state. Initial analysis of these data, in aggregate, suggests the timing of migrations and duration of wintering. The Wolf Lake female departed Wolf Lake approximately 11 September 2014 and arrived on the ocean on 12 October 2014. It is uncertain if the loon immediately left for the ocean or staged on nearby lakes before departing. The loon stayed on the ocean from 12 October 2015 through 14 April 2015; a total of 186 days. The spring migration was initiated on 14 April 2015 and ended with arrival on the breeding lakes around 3 May 2015 for a spring migration of 19 days.

6.4 MANAGEMENT ACTIONS IN NORTHWESTERN WYOMING

As the understanding of the observed territories of Common Loons in the NW Wyoming population and threats against them continues to expand, management actions mitigating these threats are being enacted. During the 2015 breeding season, we initiated the largest management effort to date, including the first deployment of a loon nest raft in Wyoming.

Bergman Reservoir

The 2015 breeding season was the first time chicks were documented to hatch and survive beyond 6 weeks of age on this territory. With Bergman Reservoir often going dry in late summer due to gradual water level draw downs for agricultural purposes, these chicks were prematurely abandoned by their parents and put at risk of being stranded without enough water to make initial flights and exposed to predation. The option of translocating these chicks to more suitable habitat in the region was explored by BRI and WGFD; however, WGFD and CTNF were able to work with the water manager to release water from Indian Lake to keep Bergman Reservoir at a suitable water level. The chicks fledged successfully and this situation will be monitored closely in subsequent years. Prior to the summer, an outfitter's permit that includes use of Bergman Reservoir came up for renewal and language was added to protect nesting loons.

Beula Lake

Beula Lake is a popular destination for park visitors, and the loon pair nests near the end of a trail with little cover around the nest site. During the 2015 season, a temporary closure was enacted restricting access to the trail along the western shore of the lake. Despite the closure being posted, some people were observed in the restricted area. The pair persisted late into the incubation period, but the nest failed due to unknown causes.

Wolf Lake

In 2014, part of the Wolf Lake's shoreline and campsite 4G6 were temporarily closed due to nesting loons, but the nest failed due to human disturbance. In 2015, the same closure was enacted pre-nesting when the pair displayed courtship and pre-nesting behavior. The closure contributed to the pair's success in hatching and rearing one chick.

Riddle Lake

Similar to 2014, access to Riddle Lake and the Riddle Lake trail was restricted to the public due to nesting Trumpeter Swans (*Cygnus buccinator*). The loon pair nested, but the outcome of the nest is unknown and no chicks were observed during aerial surveys.

Yellowstone Lake – Flat Mountain Arm (FMA)

The FMA pair nested on the sandbar again in 2015, and temporary closures were enacted to protect the nest site from human disturbance. The campsite at 7L7 was closed, as was access to the entire sandbar at campsite 7L7. Signs were posted along the sandbar and a floating sign was placed off the northern end of the sandbar to alert visitors paddling through the area. The pair failed nesting twice, with human disturbance highly suspected as the primary cause of nest failure for each attempt. One egg was collected from the nest site to be analyzed for mercury, and no development of the embryo was detected.

Yellowstone Lake - Gillnetting Restrictions

Some adjustments to gillnetting methods were enacted in 2015 to reduce the chance of loon bycatch in loon territories on Yellowstone Lake. In the area of the FMA territory, nets were set at 197 feet (60 m) or deeper, as loons typically forage in the littoral zone and target fish in the 4- to 6-inch (10- to 15-cm) size class found in shallower water (Barr 1996). While loons have been detected at depths greater than 197 feet (60 m; Evers 1994, Evers 2007), it is unlikely a loon would be foraging this deep during the breeding season. In the South Arm, gillnetting near Peale Island was limited to overnight sets only. Loons are diurnal predators, so restricting netting during daytime reduces the chance of bycatch.

To further reduce the exposure of the Peale Island loon pair to bycatch, these nighttime net sets were deployed starting at the furthest away points from Peale Island and picked up the following morning starting at points closest to Peale Island.

Lower Slide Lake – Loon Nest Raft

Although no pair has been observed occupying Lower Slide Lake since 1989, a nest raft was deployed there late in the breeding season. There were two objectives to this action: 1) entice a loon pair to establish a territory, and 2) gauge reactions of loons, lake visitors, and wildlife to the nest raft. The NW Wyoming population is projected to increase in the number of adults in the near future, resulting in added adults either attempting to take over existing territories or colonizing new ones (McIntyre 1988, Piper et al. 1997, Piper et al. 2015). Placing a nest raft at Lower Slide Lake will increase the habitat quality of this lake and may entice an unpaired adult to attempt to establish a territory. It is common for loons later in the breeding season to scout potential territories for the following breeding season (Piper et al. 2000, Evers 2007, Piper et al. 2015). In an attempt to detect loons scouting the nest raft, a trail camera was set up to take a photo of the raft and surrounding area every minute from 20 July 2015 – 19 August 2015 (30 days). While no loons were detected, visitation could have been missed by the camera if it occurred outside of that date window, or only consisted of fly over scouting. Over the 30 day period, there were at least 18 human visitations including boat, kayak, canoe, paddleboard, and shoreline fishing, as well as regular beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*) activity on and around the raft. The raft will be deployed again in 2016, with subsequent redeployments being assessed annually. Additional outreach and education about the raft and loons will occur, especially if a territory is established.

6.5 GILLNET BYCATCH AND LEWIS LAKE MORTALITY EVENTS

Gillnets are used by the National Park Service in Yellowstone Lake for the removal of invasive Lake Trout (*Salvelinus namaycush*). On 29 September 2015, the Cygnet Lake female (banded in 2015) was caught as bycatch and subsequently drowned in a gillnet set in the West Thumb near Potts Basin. The identification of this loon was possible due to the uniquely numbered USGS aluminum band and unique combination of color bands that were attached to this bird's legs when captured earlier in the breeding season. A full post-mortem examination of this carcass will be performed during the summer of 2016.

The Lewis Lake male died sometime between the end of the breeding season 2014 and late spring 2015. The initial survey of the Lewis Lake territory indentified one loon behaving territorially in and around the channel. A follow up survey revealed evidence of a loon predation or carcass scavenge site on the shore of the channel near the 2014 nest site. Despite multiple extensive searches of the area, a carcass was not recovered. In addition to the evidence of predation/scavenging, a broken loon egg from a 2015 nest was also found between the scavenge/predation site and the 2014 nest site. Three scenarios offer possible explanations for what happened to the Lewis Lake male: 1) The Lewis Lake male did not migrate in 2014 and died in the channel and was scavenged after ice-out or snow melt; 2) The Lewis Lake male migrated and returned in spring 2015, but either died or was killed by an intruding loon or predator after nesting; or 3) The predated/scavenged loon was not the Lewis Lake male. Subsequent surveys did not detect the 2014 Lewis Lake male or any further territorial behavior.

7.0 DISCUSSION

7.1 WYOMING LOON POPULATION STATUS AND HISTORICAL PERSPECTIVE

The observed NW Wyoming breeding loon population increased from 16 pairs in 2014 to 17 pairs in 2015, and continued the recent increase in territorial pairs since the decline that began in 2007 (Figure 3). It is possible that the additional pairs at Tanager Lake and Ranger Lake were present in previous years and were undetected, but their presence is more likely explained by high productivity 3 to 6 years ago contributing to population growth (Figure 4). Chicks produced during that time frame likely returned as adults three summers after fledging and either obtained existing territories or established new territories.

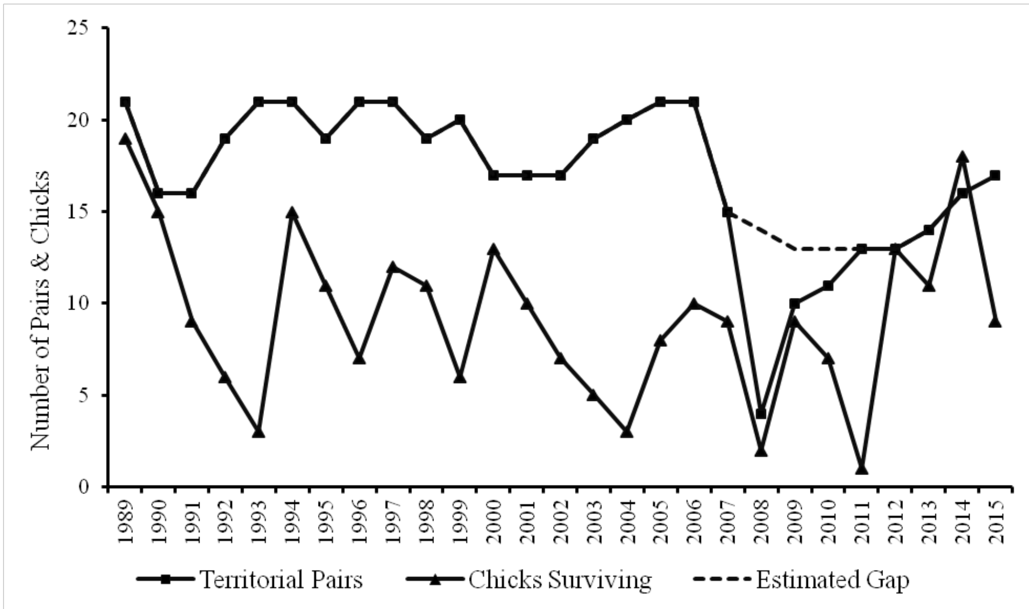

Figure 3: Number of surveyed northwestern Wyoming study area territorial pairs and chicks surviving 1989 – 2015. The pair count in 2008 and 2009 is roughly estimated (dotted line) due to shortfalls in monitoring in YNP during those years.

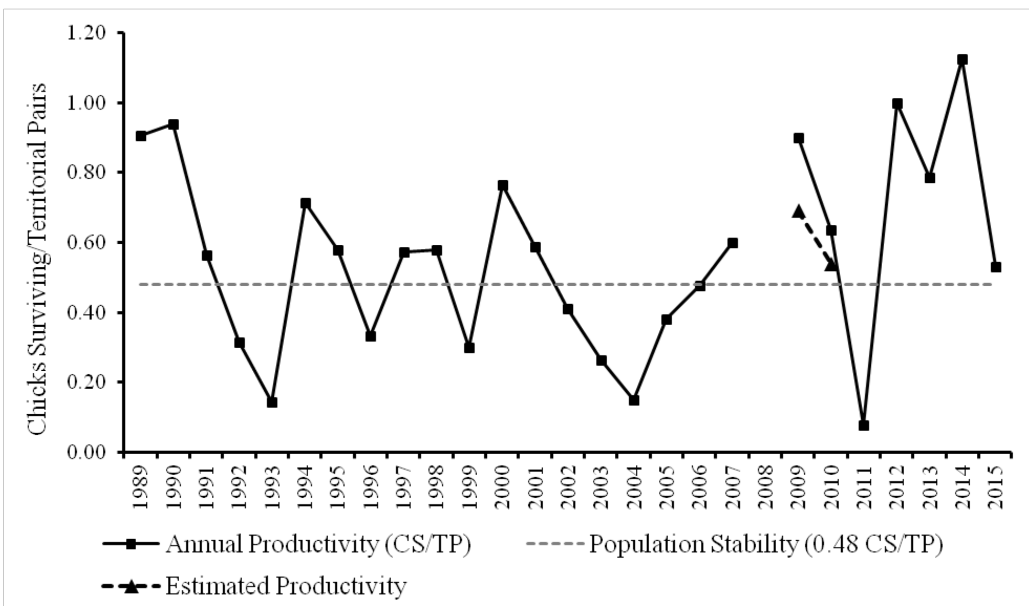

Figure 4: Northwestern Wyoming study area loon productivity (CS/TP) from 1989 – 2015. Productivity in 2015 declined from the high productivity over the previous three seasons. The gray dotted line represents the productivity threshold of 0.48 CS/TP estimated for population stability. In 2009 and 2010, productivity was calculated using the reported pair count (straight line + squares) and the estimated pair count (dashed line + triangles). No surveys were conducted in YNP in 2008, so productivity was not calculated for that year.

The observed increase in pair counts occurred despite two territories that produced chicks in 2014 not being occupied in 2015 (Shoshone Lake – East, and South Arm – West). It is uncertain why these territories were unoccupied despite being productive, but it may suggest that these territories were newly formed territories; poorer quality habitat; and/or possibly occupied by younger, less experienced breeders. With the loss of at least one pair member from a well established territory (Cygnet Lake), more changes in the distribution of pairs may occur in 2016. In 2015, the Grassy Lake Road region had pairs occupying every historic territory, as well as unpaired adult presence. New pairs may form in the future or individuals may disperse to other unoccupied historic territories.

7.2 UNDERSTANDING THE WINTERING RANGE OF THE WYOMING LOON POPULATION

Discovering the wintering location of the Wolf Lake female is a critical aspect of the conservation of the Wyoming Common Loon Population. Based on band return data, Montana loons winter from northern California to southern California, and wintering loons are found in medium and high densities in southern California and the northern end of the Sea of Cortez (Evers 2007). The wintering area of the Wolf Lake female at the southern end of the Baja Peninsula is roughly 497-932 miles (800-1,500 km) further south of these areas. Across the loons' range, interior populations, which tend to have a longer migration than coastal populations, compensate wing loading limitations by reducing body weight and/or increasing wing aspect ratio and surface area (Pennycuick 1989, Mager et al. 2007). The one-way migration distance of more than 1,490 miles (2,400 km) largely explains the small size of Wyoming loons (Males average 3,914 g, *N*=6; Females average 3,063 g, *N*=6) compared to the neighboring population in Montana (Males average 4,659 g, *N*=54; Females average 3,830 g, *N*=54).

While it is now known where the Wolf Lake female wintered, it is only one location and may not be representative of the whole Wyoming population's wintering range. Identifying this range is important for understanding what threats and risks this population endures on the wintering grounds, as well as during migration. Additional geolocator and band resight data over time will continue to describe the winter range. Wyoming loons may have a second wintering area in the Gulf of Mexico, with precedence for this split established by NW Wyoming American White Pelicans (*Pelecanus erythrorhynchos*). In

North America, eastern American White Pelicans winter along the Atlantic and Gulf of Mexico coasts and western American White Pelicans winter along the Pacific coast, but banding data show that American White Pelicans in NW Wyoming winter along both the Pacific coast and in the Gulf of Mexico (Anderson and Anderson 2005). The migration distance of 1,305+ miles (2,100+ km) from NW Wyoming to the Gulf of Mexico aligns with the weights of Wyoming loons.

7.3 COMMON LOON BYCATCH ON YELLOWSTONE LAKE

Bycatch in gillnets is a cause of Common Loon mortality on Yellowstone Lake. Since 1996, gillnets have been used to control invasive lake trout on Yellowstone Lake (Martinez et al. 2009). Efforts were intensified starting in 2001 and have increased annually since then (Bigelow et al. 2003). In 2011, YNP began hiring commercial netters for lake trout control from ice-out to ice-in, and in that year 26,777 units of effort (one unit of effort = 100 m of gillnet set over one night) were deployed (Koel et al. 2012).

Loons can become entangled in nets, as they are attracted to fish activity and enter the net area. Nets set in deep areas will drown loons, while shallow-set nets cause loons to struggle at the surface and eventually perish (Evers 1994, Evers 2007). Common Loons regularly occur as bycatch in marine gillnetting operations (Forsell 1999, Warden 2010).

The bycatch mortality of the Cygnet Lake female marks a critical point in the conservation of the NW Wyoming loon population. This is the first time a Yellowstone Lake bycatch mortality can be confirmed as a loon from the Wyoming breeding population. Prior to this event, it was debatable if loons killed as bycatch were from the local population or southward migrants from more northern populations. The timing of this mortality (29 September 2015) also shows that loons killed outside of the breeding season can be local loons. The Cygnet Lake territory is approximately 16 miles (25 km) from where the bycatch occurred in Potts Basin. Late season monitoring in NW Wyoming suggests that loons vacate their territories by mid-September and are likely moving to larger lakes, such as Yellowstone Lake and Jackson Lake, to socialize and stage for migration. Wyoming loons from Yellowstone Lake territories are vulnerable to bycatch mortality during the breeding season, and loons from non-Yellowstone Lake territories are also vulnerable to bycatch mortality before and after occupying their territories.

The loss of the Cygnet Lake female is significant to the NW Wyoming breeding population. The Cygnet Lake territory is the most productive territory in YNP and the second most productive territory in NW Wyoming. The loss of the Cygnet Lake female may impact loon short-term productivity in northern Yellowstone if this high quality territory remains vacant for one or more breeding seasons. If a new pair forms at Cygnet Lake, unpaired loons sensing a weak pair bond may contest for the territory, causing disruptions in breeding.

8.0 RECOMMENDATIONS FOR 2016

8.1 MONITORING AND BANDING EFFORT

Monitoring efforts should continue, with a focus on remote territories as well as continued tracking of unpaired adults to detect the formation of new pairs. These surveys should be started as early as possible, as some pairs may form and breakup by mid-June. Territories with nest failures suspected to be caused by human disturbance or predation, as well as repeated nest failures due to unknown reasons, should be monitored closely using trail cameras or more regular surveys, including Flat Mountain Arm (Yellowstone Lake), Lewis Lake, Beula Lake, Wolf Lake, South Arm (Yellowstone Lake), Loon Lake, and Tanager Lake. Areas outside of the NW Wyoming study area should be opportunistically surveyed to detect the presence of resident loons, including but not limited to the following lakes and areas: Wind River Range, Hebgen Lake in Montana, and Henrys Lake and Island Park Reservoir in Idaho.

The continued capture and banding of adults and chicks will aid in determining the demographics of this population, and building genetic, morphometric, mercury, and overall health profiles for this population. Capture efforts should be focused on loons that have geolocators and pairs in YNP that may be at higher risk of bycatch mortality due to habitation on or proximity to Yellowstone Lake. Banding of the Wyoming population, particularly loons on Yellowstone Lake and other nearby lakes, will increase the understanding of loon mortality in NW Wyoming and on wintering grounds. Juvenile loons should be captured to aid in understanding juvenile survivorship, dispersal, and age-related life history.

8.2 MANAGEMENT, RESEARCH, AND OUTREACH DIRECTIONS

Management, research, and outreach recommendations for the 2016 season include but are not limited to: 1) Deploy nest rafts at nest sites identified as high risk of nest failure due to human disturbance, predation, and/or fluctuating water levels; 2) Enact additional temporary closures, where appropriate, to avoid human disturbance of sensitive nesting and chick-rearing areas; 3) Continue adjustments and implementation of technology to reduce the bycatch of loons and other diving birds on Yellowstone Lake; 4) Investigate stable isotopes of invertebrate prey on fishless lakes and lakes with low fish abundance; 5) Increase public outreach and education of park guests and NW Wyoming residents.

These research and management directions will be outlined in more detail in the Wyoming Loon Work Plan (BRI unpublished report), which will be revised every 3 years and reviewed by the Wyoming Loon Working Group.

9.0 WIND RIVER RANGE SURVEY EFFORT

Loon occupancy surveys were conducted in the lake-dense Wind River Range area in June, July, and early August, 2015. This range is located southeast of Wyoming's current breeding population of loons and encompasses over 1,300 lakes. Anecdotal reports and eBird (an on-line bird observation forum) reports suggest that loons are readily using these lakes during spring and fall migration. A limited number of reports suggest that loons may also be occupying lakes in the area during the breeding season. Our primary goals were to: 1) Locate resident pairs (reside in the area during the breeding season) or individual loons in this region; 2) Evaluate the suitability of breeding habitat for lakes with loon sightings; and 3) Evaluate overall Wind River Range loon breeding habitat and best methods for surveying suitable habitat in subsequent years.

As mentioned in the Introduction of this report, Common Loons exhibit limited dispersal propensity from their natal lakes [~8 miles (13 km); Evers et al. 2000], so lakes adjacent to productive pairs have been monitored for loon presence by BRI since 2012. To determine whether current Common Loon resident distribution extends beyond the known core population, aerial, ground, and boat surveys were conducted on 88 lakes. We selected survey lakes based on previous sightings (e.g., eBird, reports from local biologists), accessibility (for those lakes not surveyed by plane), and presence of suitable foraging and nesting habitat. Survey efforts began 1 June 2015 and 3 June 2015 with two aerial surveys through Sky Aviation of Dubois, Wyoming. Seventeen lakes were still fully or partially frozen during these surveys (Table 4) making them presumably unsuitable loon habitat due to the severe contraction of the nesting period.

Table 4: Lakes with ice cover as observed during aerial surveys in the Wind River Range, 2015. Lakes with no ice cover are not included in this table.

Lake Name	Elevation (ft)	Survey Date	Loons Present (Y/N)	Full Ice Cover	Partial Ice Cover
Christina Lake	9955	1-Jun	N	x	
Divide Lake	9676	3-Jun	N	x	
Fiddlers Lake	9433	1-Jun	N		x
Hobbs Lake	10074	3-Jun	N		
Horseshoe Lake	9457	3-Jun	N		x
Kirkland Lake	9989	1-Jun	N	x	
Little Sandy Lake	9494	1-Jun	N		x
Moon Lake	9711	1-Jun	N	x	
Movo Lake	9394	1-Jun	N		x
Native Lake	9611	1-Jun	N		x
No Name 2	9578	1-Jun	N		x
Ross Lake	9691	1-Jun	N		x
Scab Lake	9515	3-Jun	N		x
Section Corner Lake	9245	3-Jun	N		x
Shoshone Lake	9516	1-Jun	N	x	
Trapper Lake	9682	3-Jun	N	x	
Wolf Lake	9584	1-Jun	N		x

A total of four adult loons were observed during the survey period (Figure 5). On the initial aerial survey, single adult loons were observed on Blueberry Lake, Star Lake, and Willow Lake (Appendix A: Wind River Range Survey Results). Each of these three sightings was followed up with additional surveys (Table 5), and only Blueberry Lake, surveyed 2 days after the initial visit, resulted in a second loon observation. A visit to this lake 12 days later found no loons. Lake of the Woods initially had no loons during the 1 June 2015 aerial survey; however, one loon was observed on this lake nearly two months later on 26 July 2015. All four lakes with confirmed loon sightings had the necessary characteristics for loon breeding habitat, including nesting areas, adequate surface area and depth, and prey availability.

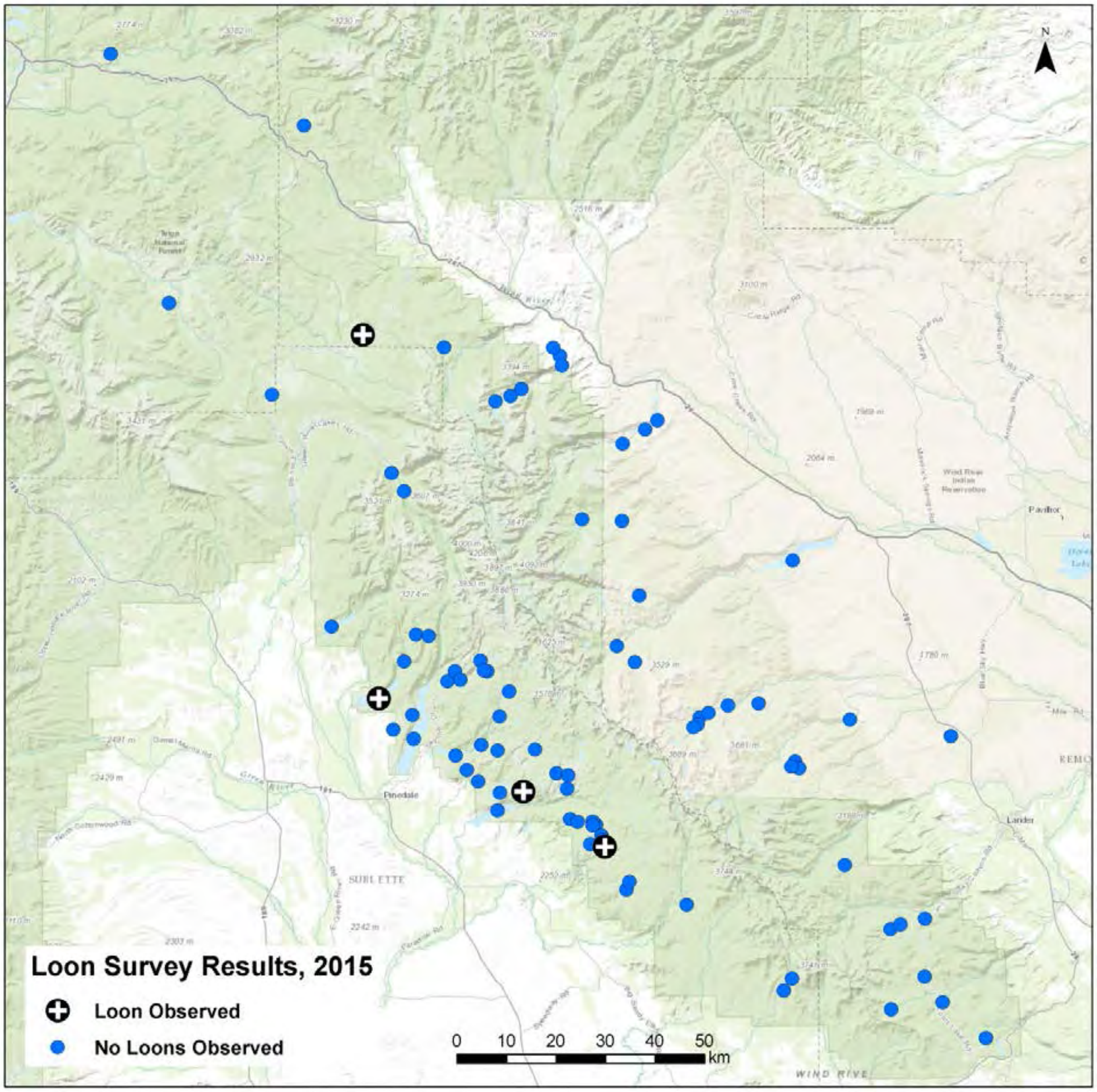

Figure 5: Locations of lakes surveyed for Common Loons in the Wind River Range, 2015.

Table 5: Lakes with repeat surveys for Common Loon presence in the Wind River Range, 2015. The symbol * indicates a report from a U.S. Fish and Wildlife Service biologist.

Lake Name	Initial Visit	Survey Type	Loon Presence	Revisit Date	Survey Type	Loon Presence	Revisit Date	Survey Type	Loon Presence
Blueberry Lake	3-Jun	Flight	1 Adult	5-Jun	Shore	1 Adult	17-Jun	Shore	0
Burnt Lake	3-Jun	Flight	0	8-Jul	Boat	0			
Dinwoody Lake	1-Jun	Flight	0	28-Jul	Shore	0			
Divide Lake	3-Jun	Flight	0	30-Jun	Shore	0			
Fiddlers Lake	1-Jun	Flight	0	29-Jul	Shore	0			
Frye Lake	1-Jun	Flight	0	29-Jul	Shore	0			
Lake Louise	1-Jun	Flight	0	29-Jul	Shore	0			
Lake of the Woods	1-Jun	Flight	0	26-Jul	Shore	1 Adult	4-Aug	Shore	0
Little Half Moon	3-Jun	Flight	0	25-Jun	Shore	0			
L. Green River Lake	3-Jun	Flight	0	27-Jul	Shore	0			
Meadow Lake	3-Jun	Flight	0	25-Jun	Shore	0			
Movo Lake	1-Jun	Flight	0	29-Jun	Flight*	0			
Raft Lake	1-Jun	Flight	0	29-Jun	Flight*	0			
Ray Lake	1-Jun	Flight	0	28-Jul	Shore	0			
Scab Lake	3-Jun	Flight	0	30-Jun	Shore	0			
Star Lake	3-Jun	Flight	1 Adult	30-Jun	Shore	0			
U. Dinwoody Lake	1-Jun	Flight	0	28-Jul	Shore	0			
U. Green River Lake	3-Jun	Flight	0	27-Jul	Shore	0			
Washakie Reservoir	1-Jun	Flight	0	28-Jul	Shore	0			
Willow Lake	6-Jul	Boat	1 Adult	29-Jul	Shore	0			
Worthern Meadows	1-Jun	Flight	0	29-Jul	Shore	0			
Wolf Lake	1-Jun	Flight	0	3-Jun	Flight	0			

Table 6: Habitat characteristics for lakes with Common Loon sightings, Wind River Range, 2015.

Lake Name	Nesting Habitat (Y/N)	Fish Presence (Y/N)	Fisherman Activity	Key Fish Species	Access	Other notes
Blueberry Lake	Y	Yes	Fisherman hike in to fish shoreline	Trout species	Hike in	
Lake of the Woods	Y	Yes	Unknown	Cutthroat Trout, Grayling	Drive up, no boat launch	Report of loon here between BRI surveys
Star Lake	Y	Unknown	Unknown	Unknown	Hike in	
Willow Lake	Y	Yes	Fishing from boat	Various Trout species, Sockeye Salmon	Drive up, boat launch	

While the survey efforts were by no means exhaustive, the late summer presence of loons on four lakes with quality habitat during the breeding season is encouraging evidence of resident loons in the Wind River Range area. These results highlight the potential for the Wind River Range area to support a breeding population of loons, as well as possible expansion of the current breeding population into this habitat. This effort forms the baseline of loon monitoring and will support future conservation efforts in the Wind River Range.

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10.0 LITERATURE CITED

Akcakaya, H.R. 1998. RAMAS GIS: Linking Landscape Data with Population Viability Analysis (version 3.0). Applied Biomathematics, Setauket, NY.

Alvo, R. 1981. Marsh nesting of Common Loons (*Gavia immer*). Canadian Field-Naturalist 95:357.

Anderson, J.G. and K.B. Anderson. 2005. An analysis of band returns of the American white pelican, 1922 to 1981. Waterbirds 28(sp1):55-60.

Anderson, C., A. Byrd, J. Paruk, V. Spagnuolo, C. Persico, and D.C. Evers. Montana Common Loon (*Gavia immer*) Summary Report. 2013. Report # 2014-05. Biodiversity Research Institute, Gorham, ME.

Barr, J. F. 1986. Population dynamics of the Common Loon (*Gavia immer*) associated with mercury-contaminated waters in northwestern Ontario. Occ. Paper 56, Canadian Wildlife Services, Ottawa, Ontario.

Barr, J.F. 1996. Aspects of Common Loon (*Gavia immer*) feeding biology on its breeding ground. Hydrobiologia 321:119-144.

Bigelow, P.E., T.M. Koel, D. Mahony, B. Ertel, B. Rowdon, and S.T. Olliff. 2003. Protection of native Yellowstone cutthroat trout in Yellowstone Lake, Yellowstone National Park. Wyoming. Technical Report NPS/NRWRD/NRTR-2003/314. National Park Service, Water Resources Division, Fort Collins, CO.

Biodiversity Research Institute. 2014. Protocol for Capturing and Banding Loons. Unpublished report #2014-17, Biodiversity Research Institute, Portland, ME.

Biodiversity Research Institute. 2014. Tissue Sampling Protocol for Loons. Unpublished report #2014-18, Biodiversity Research Institute, Portland, ME.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22:361-369.

Christenson, B.L. 1981. Reproductive ecology of and response to disturbance by Common Loons in Maine. M.S. Thesis, University of Maine, Orono, ME.

Dahmer, P.A. 1986. Use of aerial photographs to predict lake selection and reproductive success of Common Loons in Michigan. M.S. Thesis, Univ. Mich., Ann Arbor, MI.

Evers, D.C. 1993. A replicable capture method for adult and juvenile Common Loons on their nesting lakes. Pp. 214-220 in L. Morse, S. Stockwell, and M. Pokras (eds.). Proc. 1992 Conf. Loon and its ecosystem. U.S. Fish. Wildl. Serv., Concord, NH.

Evers, D.C. 1994. Endangered and threatened wildlife of Michigan. Univ. Mich. Press, Ann Arbor, MI.

Evers, D.C. 2000. An update of North America's Common Loon breeding population. Pp. 91-94 in J.W. McIntyre and D.C. Evers (eds.). Loons: Old history and new findings. Proceedings of a symposium from the 1997 meeting, American Ornithologists' Union. North American Loon Fund, Holderness, NH.

Evers, D.C. 2001. Common Loon population studies: Continental mercury patterns and breeding territory philopatry. Ph.D. dissertation. Univ. of Minnesota, St. Paul, MN.

Evers, D.C., N.M. Burgess, L. Champoux, B. Hoskins, A. Major, W.M Goodale, and T. Daigle. 2005. Patterns and interpretation of mercury exposure in freshwater avian communities in northeastern North America. Ecotoxicology 14(1-2):193-221.

Evers D. C. 2006 Loons as biosentinels of aquatic integrity. Environ Bioindicators 1:18–21

Evers, D.C. 2007. Status assessment and conservation plan for the Common Loon (*Gavia immer*) in North America. U.S. Dept. of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP, Washington, D.C. 123pp.

Evers, D.C., V. Spagnuolo, and K. Taylor. 2013. Restore the Call: Wyoming Status Report for the Common Loon. Biodiversity Research Institute, Gorham, Maine. Science Communications Series BRI 2013-21. 8pp.

Evers, D.C., L.J. Savoy, C.R. DeSorbo, D.E. Yates, W. Hanson, K.M. Taylor, L.S. Siegel, J.H. Cooley Jr., M.S. Bank, A. Major, K. Munney, B.F. Mower, H.S. Vogel, N. Schock, M. Pokras, M.W. Goodale, and J. Fair. 2008. Adverse effects from environmental mercury loads on breeding Common Loons. Ecotoxicology 17.2:69-81.

Evers, D.C., J.D. Paruk, J.W. McIntyre, and J.F. Barr. 2010. Common Loons (*Gavia Immer*). The Birds of North America Online (A. Poole, Ed). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/313doi:10.2173/bna.313.

Fair, J. 1979. Water level fluctuations and Common Loon nest failure. Pp. 57-62 in S. A. Sutcliffe (ed.). Proceedings of North American Conference on Common Loon research and management. National Audubon Society, Washington, D.C.

Forsell, D.J. 1999. Mortality of migratory waterbirds in mid-Atlantic coastal anchored gillnets during March and April, 1998. U.S. Fish Wildlife Service, Chesapeake Bay Office, Annapolis, MD.

Grear, J.S., M.W. Meyer, J.H. Cooley, A. Kuhn, W.H. Piper, M.G. Mitro, and D.E. Nacci. 2009. Population growth and demography of Common Loons in the northern United States. Journal of Wildlife Management 73(7):1108-1115.

Gostomski, T.J., and D.C. Evers. 1998. Time-activity budget for Common Loons, *Gavia immer*, nesting on Lake Superior. Canadian Field-Naturalist 112:191-197.

Hanson, E.W., C.C. Rimmer, and J. Gobeille. 2002. The 2001 breeding status of Common Loons in Vermont. Unpubl. Rept., Vermont Inst. of Natural Science, Woodstock, VT.

Heimberger, M., D. Euler, and J. Barr. 1983. The impact of cottage development on Common Loon reproductive success in Central Ontario. Wilson Bull. 95: 431-439.

Jung, R. E. 1987. An assessment of human impact on the behavior and breeding success of the Common Loon (*Gavia immer*) in the northern Lower and eastern Upper Peninsulas of Michigan. University of Michigan, Ann Arbor, MI.

Kaplan, J. D. 2003. Human recreation and loon productivity in a protected area, Isle Royale National Park. M.S. Thesis, Mich. Tech. Univ., Houghton, MI.

Kelly, L. M. 1992. The effects of human disturbance on Common Loon productivity in northwestern Montana. M.S. Thesis, Montana State Univ., Bozeman, MT.

Koel, T.M., J.L. Arnold, P.E. Bigelow, P.D. Doepke, B.D. Ertel, and M.E. Ruhl. 2012. Yellowstone Fisheries and Aquatic Sciences: Annual Report, 2011. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-2012-03.

Loon Preservation Committee. 2004. Field collection protocol for surveying and managing Common Loons in New Hampshire. Unpublished report, Loon Preservation Committee, Moultonborough, NH.

Mager III, J.N., C. Walcott, and D. Evers. 2007. Macrogeographic variation in the body size and territorial vocalizations of male Common Loons (*Gavia immer*). Waterbirds, 30(1):64-72.

Mager, J.N., C. Walcott, and W.H. Piper. 2010. Common Loons can differentiate yodels of neighboring and non-neighboring conspecifics. Journal of Field Ornithology 81:392-401.

Martinez, P.J., P.E. Bigelow, M.A. Deleray, W.A. Fredenberg, B.S. Hansen, N.J. Horner, S.K. Lehr, R.W. Schneidervin, S.A. Tolentino, and A.E. Viola. 2009. Western lake trout woes. Fisheries 34(9):424-442.

Maxwell, M.H. 1993. Avian blood leukocyte responses to stress. World's Poultry Science Journal 49:34-43.

McIntyre, J. 1988. The Common Loon: Spirit of northern lakes. Univ. Minn. Press, Minneapolis, MN. 228pp.

McIntyre, J.W., and J.F. Barr. 1997. Common Loon: Birds of North America. Academy of Natural Sciences, Philadelphia, PA.

Mitro, M.G., D.C. Evers, M.W. Meyer, and W.H. Piper. 2008. Common loon survival rates and mercury in New England and Wisconsin. Journal of Wildlife Management 72(3):665-673.

Olson, S., and W.H. Marshall. 1952. The Common Loon in Minnesota. Minn. Mus. Natural History, Univ. of Minn., Minneapolis, MN.

Pennycuick, C. J. 1989. Bird flight performance: A practical calculation manual. Oxford Univ.Press, Oxford, England.

Piper, W.H., K.B. Tischler, and M. Klich. 2000. Territory acquisition in loons: the importance of take-over. Animal Behaviour, 59(2):385-394.

Piper, W.H., J.N. Mager, C. Walcott, L. Furey, N. Banfield, A. Reinke, F. Spilker, and J.A. Flory. 2015. Territory settlement in Common Loons: no footholds but age and assessment are important. Animal Behaviour 104:155-163.

Pulliam, H.R., and B.J. Danielson. 1991. Sources, sinks, and habitat selection: A landscape perspective on population dynamics. American Naturalist 137:S50-S66.

Reiser, M. H. 1988. Effects of regulated lake levels on the reproductive success, distribution, and abundance of the aquatic bird community in Voyageurs National Park, Minnesota. National Park Service Research/Resource Management, Report MWR-13, Omaha, NE. 67pp.

Ruggles, A. K. 1994. Habitat selection by loons in southcentral Alaska. Hydrobiologia 279/280:421-430.

Spagnuolo V., C. Persico, M. Kneeland, J. Fair, J. Paruk, A. Byrd, and D.C. Evers. 2014. Wyoming Common Loon (*Gavia Immer*) Summary Report, 2013. Biodiversity Research Institute, Gorham, Maine. Report #2014-06.

Strong, P.I.V., and J.A. Bissonette. 1989. Feeding and chick-rearing areas of Common Loons. Journal of Wildlife Management 53:72-76.

Strong, P.I.V., Bissonette, J.A., and Fair, J.S. 1987. Reuse of nesting and nursery areas by Common Loons. Journal of Wildlife Management 51: 123-127.

Sutcliffe, S.A. 1980. Aspects of the nesting ecology of Common Loons in New Hampshire. M.S. thesis. Univ. New Hampshire, Durham, NH.

Titus, J.R. and L.W. Van Druff. 1981. Response of the Common Loon to recreational pressure in the Boundary Waters Canoe Area, Northeastern Minnesota. Washington: Wildlife Society.

Valley, P.J. 1987. Common Loon productivity and nesting requirements on the Whitefish chain of lakes in North-Central Minnesota. The Loon 59:3-10.

Vleck, C.M., N. Vertalino, D. Vleck, and T.L. Bucher. 2000. Stress, corticosterone, and heterophil to lymphocyte ratios in free-living Adelie Penguins. Condor 102:392-400.

Warden, M.L. 2010. Bycatch of wintering common and red-throated loons in gillnets off the USA Atlantic coast. Aquatic Biology 10:167-180.

Yates, D., L. Savoy, and D.C. Evers. 2002. Flagstaff Lake Common Loon Population Survey and Management Report, 2002. BRI Report 2002-16, submitted to FPL Energy Maine Hydro. BioDiversity Research Institute, Falmouth, ME.

Yonge, K.S. 1981. The breeding cycle and annual production of the Common Loon (*Gavia immer*) in the boreal forest region. M.S. Thesis, Univ. Manitoba, Winnipeg.

Appendix A: Lakes surveyed for Common Loons in the Wind River Range, 2015.

Lake Name	Latitude	Longitude	Elevation (ft)	Survey Date	Loon Presence	Other Species Observed	Survey Type	Follow Up Survey
Alpine Lake	43.0691917	-109.4377281	8985	1-Jun		mergansers	Plane	
Black Lake	42.9307942	-109.6539298	9262	3-Jun			Plane	
Blueberry Lake	42.8761198	-109.6080853	8476	3-Jun	1 Adult		Plane	Yes
Boulder Lake	42.8510612	-109.6541072	7301	8-Jul		grebes	Boat	
Boutler Lake	42.7259138	-109.3112543	9240	1-Jun			Plane	
Brooks Lake	43.7548289	-110.0052467	9069	5-Aug		grebes, goldeneye	Shore	
Bull Lake	43.1826598	-109.1190483	5818	1-Jun		grebes	Plane	Yes
Burnt Lake	42.8746692	-109.6498319	7916	3-Jun			Plane	Yes
Chris Lake	42.9004248	-109.5474386	9255	3-Jun			Plane	
Christina Lake	42.5861450	-108.9398233	9955	1-Jun			Plane	
Cottonwood Lake	42.7459901	-109.4207070	9571	3-Jun			Plane	
Deadman Lake	43.0479554	-109.4050994	9286	1-Jun			Plane	
Dinwoody Lake	43.3675516	-109.3639887	6488	1-Jun			Plane	Yes
Divide Lake	42.8319260	-109.4756452	9676	3-Jun			Plane	Yes
Fayette Lake	42.9380610	-109.6841818	7956	3-Jun		goldeneye	Plane	
Fiddlers Lake	42.6298456	-108.8795890	9433	1-Jun		mergansers, waterfowl	Plane	Yes
Fremont Lake	42.9464265	-109.8062600	7430	7-Jul		ospreys	Boat	
Frye Lake	42.7071162	-108.8788737	8510	1-Jun			Plane	Yes
Gorge Lake	43.0499421	-109.6851330	8860	3-Jun		mergansers	Plane	
Half Moon Lake	42.9242147	-109.7305020	7610	7-Jul		ospreys	Boat	
Hidden Lake	43.3993026	-109.6306470	9257	1-Jun			Plane	
Hobbs Lake	43.0357249	-109.6727090	10074	3-Jun			Plane	
Horseshoe Lake	42.9322835	-109.5861291	9457	3-Jun			Plane	
Junction Lake	42.9761714	-109.6504636	9048	3-Jun		mergansers, golden eyes	Plane	Yes
Kirkland Lake	43.1361418	-109.3967850	9989	1-Jun			Plane	
Lake Ethel	42.8802712	-109.5283310	8696	3-Jun			Plane	
Lake Louise	43.4088913	-109.6106976	8419	1-Jun			Plane	Yes
Lake of the Woods	43.4796931	-109.8991095	9250	1-Jun	1 adult		Plane	Yes
Little Bob Lake	43.2349415	-109.4285420	9800	1-Jun		mergansers	Plane	
Little Divide Lake	42.8366308	-109.4817578	9630	30-Jun			Shore	
Little Half Moon Lake	42.9048952	-109.7099192	7606	3-Jun			Plane	Yes

Lake Name	Latitude	Longitude	Elevation (ft)	Survey Date	Loon Presence	Other Species Observed	Survey Type	Follow Up Survey
Little Moccasin Lake	42.9123386	-109.1163646	9360	1-Jun			Plane	
Little Sandy Lake	42.6273761	-109.1198715	9494	1-Jun			Plane	
Little Soda Lake	42.9777696	-109.8090241	7610	6-Jul		scaup	Shore	
Long Lake	42.9163580	-109.1143464	7875	3-Jun		goldeneyes, grebe sp.	Plane	
Long Lake	43.0226113	-109.7452007	9339	1-Jun			Plane	
Louis Lake	42.5959486	-108.8466544	8584	1-Jun			Plane	
Lower Green River Lake	43.2976506	-109.8467439	7965	3-Jun			Plane	Yes
Meadow Lake	42.8897731	-109.6894000	7910	3-Jun		mergansers?	Plane	Yes
Moccasin Lake	42.9071981	-109.1068527	9530	1-Jun			Plane	
Monroe Lake	42.8177968	-109.4659043	9585	30-Jun			Shore	
Moon Lake	43.4636554	-109.7515705	9711	1-Jun			Plane	
Mosquito Lake	43.4011224	-110.0633744	8895	26-Jul		2 swans, 3 cygnets, 20+ duck broods	Shore	
Movo Lake	42.9745269	-109.2874751	9394	1-Jun			Plane	Yes
Mud Lake	43.3364903	-109.4274952	6663	28-Jul		cormorants	Shore	
Native Lake	43.2368506	-109.5008660	9611	1-Jun			Plane	
New Fork Lake	43.0947624	-109.9553775	7832	6-Jul			Boat	
No Name 1	42.9650705	-109.2912165	9475	1-Jun			Plane	
No Name 2	42.9614193	-109.2984844	9578	1-Jun			Plane	
No Name 3	42.8318024	-109.4814108	9675	30-Jun			Shore	
No Name 4	42.8123396	-109.4628668	9573	30-Jun		ducks	Shore	
Norman Lakes	42.8977454	-109.5259562	9386	3-Jun			Plane	
Pole Creek Lakes	43.0091653	-109.6334287	8540	3-Jun			Plane	
Raft Lake	42.9806431	-109.2717296	9183	1-Jun			Plane	Yes
Ray Lake	42.9500237	-108.8320616	5535	1-Jun		mallards, geese, heron, grebes	Plane	Yes
Ring Lake	43.4522723	-109.5413448	7436	1-Jun			Plane	
Roaring Fork Lake	42.6930035	-108.9411542	9035	1-Jun		mallard	Plane	
Ross Lake	43.3926066	-109.6581103	9691	1-Jun			Plane	
Sapphire Lake	43.0372490	-109.6788621	10231	3-Jun		mergansers	Plane	
Scab Lake	42.8060660	-109.4861262	9515	3-Jun			Plane	Yes
Section Corner Lake	43.0847220	-109.8021835	9245	3-Jun		ducks	Plane	
Sheet Lake	42.6112286	-109.1350325	9358	1-Jun			Plane	
Shoe Lake	42.9093488	-109.1212345	9335	1-Jun			Plane	
Shoshone Lake	42.7783704	-109.0241659	9516	1-Jun			Plane	
Snake Lake	43.0486956	-109.8235186	7795	3-Jun		mergansers	Plane	

Lake Name	Latitude	Longitude	Elevation (ft)	Survey Date	Loon Presence	Other Species Observed	Survey Type	Follow Up Survey
Soda Lake	42.9583478	-109.8434136	7844	18-Jul			Shore	
Soda Lake (Gros Ventre)	43.5217363	-110.2503413	7552	6-Jul		western grebes, coots, geese	Shore	
Star Lake	42.8026288	-109.4600712	9497	3-Jun	1 Adult		Plane	Yes
Toboggan Lake 1	42.8398733	-109.5225175	9407	30-Jun		ducks	Shore	
Toboggan Lake 2	42.8362058	-109.5091829	9439	30-Jun		goldeneye?	Shore	
Torrey Lake	43.4632035	-109.5533143	7431	1-Jun		grebes	Plane	
Tracy Lake	43.8482113	-110.3560830	6976	3-Jun			Shore	
Trail Lake	43.4398212	-109.5373213	7450	1-Jun			Plane	
Trapper Lake	43.0829270	-109.7791019	9682	3-Jun			Plane	
Triangle Lake	43.0358017	-109.7313675	8895	3-Jun		mergansers	Plane	
Twin Lake	42.9903938	-109.2360003	9682	1-Jun			Plane	
Upper Dinwoody Lake	43.3553961	-109.3866276	6492	1-Jun			Plane	Yes
Upper Green River Lake	43.2739518	-109.8237916	7965	3-Jun		buffleheads, mergansers	Plane	Yes
Upper Long Lake	43.0246531	-109.7215397	7945	3-Jun			Plane	
Upper Rock Creek Reservoir	42.5481475	-108.7680909	8339	1-Jun			Plane	
Washakie Res	42.9718717	-109.0147170	6362	1-Jun			Plane	Yes
Willow Lake	42.9996891	-109.8699920	7702	6-Jul	1 Adult		Boat	Yes
Wolf Lake	42.7562673	-109.4146857	9584	1-Jun			Plane	Yes
Worthen Meadows Reservoir	42.6995623	-108.9233662	8841	1-Jun			Plane	Yes
Yahtic Lake	42.9932173	-109.1804711	8478	1-Jun			Plane	

RESOURCE SELECTION OF FERRUGINOUS HAWKS (*BUTEO REGALIS*) IN WYOMING IN RELATION TO ENERGY DEVELOPMENT: AN UPDATE

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Ferruginous Hawk

FUNDING SOURCE: United States Forest Service Rocky Mountain Research Station

PROJECT DURATION: 1 January 2010 – 31 December 2013

PERIOD COVERED: 1 January 2010 – 15 April 2016

PREPARED BY: John R. Squires, Rocky Mountain Research Station, Forestry Science Lab

SUMMARY

The rapid increase in domestic energy development in Wyoming has heightened concern of potential impacts to prairie-nesting raptors. This concern is most acute for Ferruginous Hawks (*Buteo regalis*), a species known for sensitivity to human-caused disturbance. In 2010, we surveyed 60 random townships (93.3 km^2 each) for occupied nest-sites within the species' distribution in Wyoming. In 2011, we augmented this sample by searching an additional 39 townships. We conducted flights in late April and early May when Ferruginous Hawks occupied nest territories, including laying and incubating eggs. Aerial surveys provided a representative and unbiased sample of occupied nests for resource selection modeling, regardless of road proximity, land ownership, and terrain access. We built resource selection models based on remotely-sensed covariates across Wyoming. We viewed nest selection as a hierarchical process that included multiple spatial scales, and thus evaluated the environmental features that Ferruginous Hawks select at both the immediate nest area (0.25-1 km) and within a broader landscape context (1.5-25 km). Based on an average of the 4 top performing nest-site scale models, Ferruginous Hawks selected nest areas with increased amounts of bare ground, lower topographic roughness, and shorter relative shrub heights. Ferruginous Hawks exhibited positive selection to 3 other variables at the nest-site scale (proportion of riparian land cover, oil/gas well density, and secondary road density), but these variables occurred only once in the top set of models, suggesting lower model support for each term. We also built a set of 50 combination scale candidate models using variables from both the nest-site and landscape scales. Five combination models were averaged as they were within 2 ΔAIC of the best performing models. Landscape scale topographic roughness (5 km) was the most important variable for predicting Ferruginous Hawk habitat, contributing to all 5 of the top models. Ferruginous Hawks selected areas with lower roughness that is found in areas that were flatter compared to random expectation. Ferruginous Hawks also selected areas with a greater proportion of bare ground directly around the nest-sites (250 m), which contributed to 3 of the 5 top models. Other variables included in the top models were the straight line distances to roads and wells, the

proportion of riparian land cover, and shrub height at both small (250 m) and large (25 km) scales. However, the bootstrapped confidence intervals for these variables included zero, indicating a lack of predictive importance. We evaluated model performance using both cross-validation and by calculating predicted RSF values for a withheld (N = 93) nest sample. The cross-validated combined-scale model set performed better than either the nest-site or landscape-scale model set, with a Spearman-rank correlation of 0.96 (SE = 0.03). The second, more rigorous, evaluation of model performance used the model predicted values at withheld nests to closely simulate how models would be used by resource agencies. The Spearman-rank correlation between predicted RSF values of withheld nests and random RSF values at the combined scale was 0.90. The majority of withheld nests were assigned to higher RSF probabilities, suggesting good model performance. We concluded that disturbance associated with energy development was not an important predictor of habitat selection for Ferruginous Hawks when nesting. However, anecdotal observations suggest a non-linear relationship between energy development and habitat suitability; fields with dense development may show a decline in nesting Ferruginous Hawks over time (e.g., Pinedale Anticline, Jonah Infill Drilling Project).

Although we are no longer collecting field data with crews on the ground, we still receive Geographic Positioning System (GPS) locations from 8 pairs of Ferruginous Hawks nesting in oil/gas fields. These pairs were instrumented in previous years with transmitters that still send data. In August 2016, we will begin our analysis of Ferruginous Hawk movements and resource use in oil/gas fields. Our rich dataset of Ferruginous Hawk movements in energy fields will provide a good basis to address the issue in an upcoming publication. We will also continue to monitor the winter movements of all instrumented birds. Topics that we are addressing with ongoing data analyses include:

1) Resource selection of Ferruginous Hawk and Golden Eagle (*Aquila chrysaetos*).
2) Resource selection of Ferruginous Hawk and Golden Eagle in sagebrush-steppe across Wyoming (the paper is mostly written).
3) Developing a monitoring plan for Ferruginous Hawk in cooperation with other partners (modeling is ongoing).
4) Evaluating the genetic structure of Ferruginous Hawks in Wyoming compared to other populations in Washington and Canada to understand the presence of putative populations (DNA has been extracted and we are currently modeling these data).
5) Distribution mapping of potential prey of Ferruginous Hawks/other raptors at the landscape scale across Wyoming (modeling has been completed and the paper is mostly written).
6) Movements, resource selection and spatial use of Ferruginous Hawks in oil/gas fields (mentioned above).
7) Winter movements and resource-selection of Ferruginous Hawk nesting across Wyoming.

These topics and our recent publications encompass our original vision for our Ferruginous Hawk research program. We are considering potential topics for continued work—a second phase of the study—but we have not solicited funding. All existing funds are used for data analyses and GPS-acquisition costs (GPS data are transmitted through ARGOS).

EVALUATION OF LONG-BILLED CURLEW (*NUMENIUS AMERICANUS*) REPRODUCTIVE SUCCESS, MIGRATION, AND HABITAT USE

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Long-billed Curlew

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 April 2015 – 31 March 2018

PERIOD COVERED: 1 April 2015 – 1 December 2015

PREPARED BY: Jay Carlisle, Research Director, Intermountain Bird Observatory
Stephanie Coates, Master's student, Boise State University

ABSTRACT

In 2015, Intermountain Bird Observatory (IBO) conducted a study of Long-billed Curlews (*Numenius americanus*) in Wyoming, funded through the US Fish and Wildlife Service State Wildlife Grants program, that included two main objectives: (1) assess abundance and reproductive success of breeding Long-billed Curlews on private lands in Sublette County where a previous study had been done in the 1980s, and (2) deploy four satellite transmitters on breeding adults in two populations. We documented a high density of breeding adult Long-billed Curlews between Daniel and Pinedale in Sublette County and found/monitored 31 nests from this population which had an apparent hatching success of 42%. As the Wyoming demographic study is part of an larger regional study, we contrast these data with comparable data collected at other sites in the Intermountain West in 2015, where we observed a wide range of variation in breeding Long-billed Curlew density (0.5-6.8 curlews per km) and nest success ranging from 14.4-40.4% (apparent hatch rate ranged from 23-58%). Wyoming State funding was also used to deploy four satellite transmitters on Long-billed Curlews in Wyoming – three in the Daniel/Pinedale study area and one from Bureau of Land Management lands near the Heart Mountain Ranch north of Cody in Park County. Three of these birds migrated to Mexico and one (from Daniel) went to the Imperial Valley of southeastern California. We compare these migration results with other birds that we tagged in Wyoming and in the region in 2015 and in prior years. These initial tracking data suggest that Long-billed Curlews nesting on either side of the Continental Divide in Wyoming may have different migration patterns and wintering areas. More individuals need to be tracked across the state to test this hypothesis and determine the true extent of wintering habitats and migration routes used by Long-billed Curlews that nest in Wyoming.

INTRODUCTION

The Long-billed Curlew (*Numenius americanus*; curlew) is declining in many parts of its range, and factors include habitat loss and degradation, environmental toxins, and human disturbance (Dugger and Dugger 2002). Boise State University's Intermountain Bird Observatory (IBO) has studied a population of curlews in southwestern Idaho (Long-billed Curlew Habitat Area of Critical Environmental Concern; ACEC) since 2009—a population that was first studied intensively in the late 1970s (Jenni et al. 1981). Subsequent monitoring has documented a population decline of at least 90% in just over 35 years at this study site, as well as a very low rate of reproductive success (Pollock et al. 2014). In recent years, we have expanded our curlew research to other breeding populations in the Intermountain West, including sites in Idaho, Montana, and Wyoming (Figure 1). A US Fish and Wildlife Service State Wildlife Grant (SWG) for Wyoming in 2015 provided the opportunity to reassess a breeding population in Sublette County first studied in the early 1980s (Cochran and Oakleaf 1982, Cochran and Anderson 1987), both in terms of curlew density and nesting success (Figure 2).

Though breeding season metrics are critical to conservation and management, it is also important to understand limiting factors throughout the full annual cycle. Importantly, we have directly observed some threats on breeding grounds, but others may be happening during migration and/or in wintering areas. Our knowledge about what curlews do once they leave Intermountain West breeding areas is limited (but see Page et al. 2014), hampering our ability to explain population declines. Some basic questions that we still lack information about include:

- What migratory routes do Intermountain West breeding curlews take to reach their wintering grounds?
- When do Intermountain West breeding curlews arrive on their wintering grounds and where are these sites?
- What specific habitats do they require during migration and winter?
- How extensive are movements during the winter season?

Satellite transmitters on Long-billed Curlews can provide valuable insights into the species' migratory routes, migratory timing, and habitat requirements—information that is critical to conservation planning. In recent years, researchers have attached satellite transmitters to curlews in other western states with great success, especially in terms of learning about migration routes and wintering destinations. Curlews from Montana, Oregon, Nebraska, and Nevada have been tracked to different wintering grounds (Page et al. 2014). The only historic migration data from Idaho included two curlews leg-banded in the ACEC in the 1970s that were later recovered/re-sighted in California and Haiti (R. Redmond, personal communication). We have much to learn about where curlews from Wyoming and other Intermountain West locations migrate to and spend the winter. To address this information need, since 2013 IBO has tracked 28 curlews that breed in Idaho, western Montana, or Wyoming. This includes seven tracked from Wyoming in 2015, four of which were funded by this State Wildlife Grant project. In this report we summarize reproductive data from Sublette County curlews, examine migration data from adults carrying satellite transmitters, and compare Wyoming results to those from the region. Data from this study will be further analyzed as part of a graduate research project at Boise State University scheduled for completion in 2017.

METHODS

Abundance Surveys

We timed breeding season population surveys to fall within an early season, two-to-four week window set by nationally standardized survey protocols for Long-billed Curlews (Jones et al. 2003). Timing of the survey period varied by latitude and elevation, but coincided with conspicuous aerial territory displays of males in each area. We conducted dependent, double-observer point counts with 800 m between points (Nichols et al. 2000, Jones et al. 2003, Forcey et al. 2006). For comparisons between past and current population estimates, we maintained historical road-based routes.

At each point, a primary observer detected curlews visually and aurally, while a secondary observer recorded the number of curlews detected, their compass bearing, distance using a laser rangefinder, and time detected within the 5-minute count. The secondary observer also recorded auditory or visual detections of curlews that were not detected by the primary observer. Point counts in Wyoming began after sunrise and ended by 1100 hours, and were paused during inclement weather that would affect detection abilities. At the start of each survey, observers recorded the time, temperature, percent cloud cover, and wind speed (Beaufort scale). Observers were instructed to remain within 10 m of the point count location for the duration of the count, but could relocate to acquire better distance measurements once the 5-minute count was completed.

Nest Searching/Monitoring

We searched for nests by observing behavior of adult curlews. Most often we found nests by watching key activity areas during the early morning and early evening. During these time periods, adults switch incubation duties, and we were able to observe the incubation switch and then set up an observation/approach point for a given nest. Other behavioral cues we used to find nests included pair courtship in the early season, pre-incubation activities, and predator mobbing. Spot-mapping courtship behavior as well as documenting 'scraping' and 'grass tossing' by adult curlews enabled us to focus the timing and location of our search efforts.

We minimized researcher disturbance of located nests by collecting key information during a quick first visit, and for subsequent visits monitored from afar, unless an approach was deemed necessary. First visit information included number of eggs, nest cup GPS coordinates, and age of eggs. We determined egg age by floating eggs in ambient temperature water and comparing to diagrams of the progression of floatation levels for curlew eggs at different ages (Liebezeit et al. 2007, Blake 2013). On return visits if we could not see an incubating adult from afar after viewing from different angles and distances, we eventually approached the nest to determine if it was still active. We checked the status of nests at approximately 4-day intervals. We predicted hatch dates using egg age estimates and shifted to daily visits on days surrounding predicted hatch dates to better determine nest fate. We did not approach nests in inclement weather or in the presence of predators.

Disturbance and Predator Surveys

In the 2015 field season, we quantified predator abundance as well as human disturbances. Throughout the nesting season, we conducted distance sampling along 500-m transects, and recorded observations of recreational disturbances, vehicular traffic, anthropogenic structures, and all potential mammalian and avian predators. The sampling design was stratified and systematic, with transect lines running north to south and placed at an approximate density of one transect per square kilometer in main nesting areas. We repeated the same transect two to three times during the season and varied survey timing. Surveys were completed on different days of the week and at different times of the day, and captured temporal variation of predator and human activity. Data from the disturbance and predator surveys will be analyzed as part of the graduate thesis work.

Capture, Banding, and Attachment of Satellite Transmitters

Once nests were found and birds selected for transmitters, we captured incubating adults on nests by carrying an 18-m mist-net between two biologists and dropping it over the incubating adult. The ideal method is to keep each biologist equally spaced on either side of the nest, as adults will generally remain on the nest until approached very closely. Once a successful capture is made, we transported the curlew to either a shaded location or a vehicle with air conditioning in order to keep the curlew from getting too hot or cold, and begin the banding/measuring process. In order, we:

- Placed a USGS aluminum band on one leg
- Placed a plastic alpha flag (green with two white letters) on the upper leg – opposite leg as USGS band (Figure 3)
- Measured wing chord and culmen (bill length), and weighed the bird
- Used the leg-loop harness technique to safely attach the satellite transmitter to the lower back (synsacrum)

Jay Carlisle was trained in this technique during May 2013 by Fletcher Smith of the Center for Conservation Biology (Virginia), and has since deployed 28 transmitters from 2013-2015.

Data Analysis

We estimated curlew density in the program DISTANCE (version 6.2, Thomas et al. 2010). After pooling the number of birds counted at each stop by both observers, we restricted the analysis to only include curlews determined to be in their home territories (not flying over or temporarily foraging in a site). We fit a half-normal detection function with a cosine adjustment term to the data from all sites combined, then post-stratified by site to determine density at individual sites. We also right-truncated 10% of the observations as recommended by Buckland (2001) for point counts, and used bootstrapping to calculate 95% confidence intervals.

We analyzed nest survival data in Program MARK (version 8.0, White and Burnham 1999) to calculate a constant Daily Survival Rate (DSR) and 95% confidence intervals for each site. We used the maximum likelihood version of the Mayfield model, which requires a known nest fate and age of the nest. We removed nests from the analysis that were missing either piece of information, or nests that were found at or after hatching. Nests were considered successful if at least one egg hatched. To calculate nest survival from DSR, we used the average incubation time of 28 days, and an egg-laying period of 5 days. Thus, the overall nest success of a site with DSR equal to 0.9729 is 40.4% (0.9729^{33}). We also calculated apparent hatch rate, the number of nests that hatched divided by the total number of nests, for comparison with other studies using that metric. Apparent hatch rate provides an estimate of nest success, but is inaccurate in that it does not account for logistic exposure as a Mayfield-based model does.

RESULTS

Density Estimates

Curlew density in the Daniel/Pinedale, Wyoming area was 6.8 curlews per km^2, and this was the highest density among six sites surveyed in 2015 that ranged down to $0.5/km^2$ (Table 1). A population in the Pahsimeroi Valley, Idaho had the next highest density at 5.5 curlews per km^2. The site near Cody, Wyoming was comparable in density to the ACEC in Idaho, with approximately 0.72 and 0.78 curlews per km^2, respectively. Note that these density estimates are the averages for each site, but some study sites had more than one focal point count area, and density could vary considerably between point count routes in the same study area.

Nest Success

Daily survival rates (DSR) varied between sites and, of four sites with adequate sample size (Table 2), the Daniel/Pinedale area had the highest DSR (40.4%, Figures 4 and 5). The ACEC near Boise, Idaho had the lowest (14.4%). All three nests found in the Cody, Wyoming area hatched, while roughly half of the nests the Daniel/Pinedale area hatched (Table 3). Nest initiation dates in the Daniel/Pinedale area followed a slightly right-skewed normal distribution with a mean initiation in the first week of May. Comparatively, at the ACEC the distribution of nest initiation dates was bimodal, peaking in the second week of April and again in the last week of May. This may reflect re-nesting attempts at the ACEC, and either re-nesting not occurring in the Daniel/Pinedale area, or occurring largely after our field season ended.

Of the eight curlews from nest-monitoring sites in Wyoming in 2015 that we captured, six had successful nests. We equipped five of the captured birds with satellite transmitters (Table 4). In the Cody area, we captured one adult from each of three nests, and all nests hatched successfully. In Daniel/Pinedale, three of the five nests of captured birds hatched. Of the remaining nests, one was abandoned, potentially due to flooding, and the other was depredated by a mammalian predator.

Satellite Telemetry Results

Tracking data thus far from curlews breeding in Intermountain West show several key wintering areas (Figure 6). The majority of the curlews from the ACEC, farthest west of the sites where we tagged birds, migrated to the Central Valley of California. Another key wintering site extends from California’s Imperial Valley, near the Salton Sea, down to the northern Gulf of

California (Figure 6). Our data suggest this is an important area for curlews breeding across Idaho and western Wyoming. Wintering habitat types are varied and include agricultural fields, tidal mudflats, and grasslands.

Curlews from the Daniel/Pinedale area migrated to locations farther west compared to birds from the Cody area (Figure 7). Of the three birds from Daniel/Pinedale, one migrated to near the Salton Sea in southern California, another is in northwestern Mexico in the Gulf of California, and the third curlew settled onto the western coast of the Baja peninsula after a short period in agricultural lands in the Imperial Valley of California (Figures 8-10). In contrast, the Cody curlews all migrated to inland areas of northern (Chihuahua, MX) and central Mexico (Fresnillo, MX). Though not funded by Wyoming SWG, we have also tracked three curlews from Teton County; two have migrated to the Gulf of California, while the other has spent consecutive winters near the Marismas Nacionales in western Mexico.

DISCUSSION

Relative to other sites monitored in 2015, the Daniel/Pinedale area has the highest density of breeding curlews, and this fits prior findings that this area hosted the highest density of curlews in Wyoming in the 1980s (Cochran and Oakleaf 1982, Cochran and Anderson 1987). Detectability may vary according to site conditions, including topography and vegetation; however, at present we do not have enough data from all sites to model detectability separately for each site. This and other methods of calculating density estimates will be explored, and we intend to update these analyses as needed.

Overall nest success in the Daniel/Pinedale area during the 2015 field season was the highest of the sites we monitored (40.4%, n = 25), and higher than historical estimates for the area. In 1982, overall nest success from the same study area calculated using the Mayfield method was 33.6% (n = 21; Cochran and Anderson 1987). From 2003 to 2006 in northeastern Nevada, Hartman and Oring (2009) found an overall nest success of 31% (n = 218) for nests, the majority of which were located in flood-irrigated hay fields (n = 140). Long-term monitoring would provide valuable information on inter-annual variation, as suggested by documentation of high variability in nest success between years (Hartman and Oring 2009). For comparison, historic nest success at the ACEC in southeast Idaho was 40% (Redmond and Jenni 1986), but has now fallen to less than half of that.

Several things should be taken into consideration regarding the nest success results. First, these estimates assume a constant daily survival rate, but temporal heterogeneity is likely to occur. For example, many early season nests in Daniel fell victim to snowstorms and flooding, so daily survival rates in the early season might be lower. Additionally, we have not yet incorporated other parameters such as habitat variables into the nest survival models. Finally, it appears that at some sites (such as the ACEC), curlews with failed nests attempt to re-nest. Our models of nest survival assume each nest is from a different individual. The ongoing graduate study analyses will include examination of how habitat and disturbance variables affect nest survival, as well as modeling non-constant daily survival rates.

Wyoming curlews traveled to non-breeding destinations that were farther south and farther east than curlews from any other site we tracked in the Intermountain West. They also showed high variability in habitat use in their non-breeding areas. Interestingly, approximately 25% of individual curlews make large geographical movements after 'arriving' at their non-breeding areas. This raises many questions on the topics of fidelity and adaptability to changing conditions on the non-breeding grounds. We hope to continue to explore patterns of habitat use and movements within the non-breeding season with additional transmitter data, both from birds we are currently tracking and from new birds in the future.

Future Work – Nest Success and Satellite Telemetry

Our ultimate goal is to compare/contrast curlew nesting success data across sites in Idaho, Montana, and Wyoming with various habitats, predator communities, and disturbance regimes to help complete our understanding of what limits nesting success in this species. Thus, we hope to add at least one more reproductive season in each key breeding area, including the Daniel/Pinedale site, in order to assess inter-annual variability. Results from this study and future work will greatly increase our knowledge of what limits curlew reproductive success, and will contribute to improvement of a regional conservation strategy for this species. It will also allow biologists and land managers to understand the specific risks faced by local breeding populations.

Data collected in Wyoming are contributing to a larger regional database, as we have now tracked 28 individual curlews from breeding sites in Idaho, Montana, and Wyoming from 2013-2015, including the eight from Wyoming funded by the Meg and Bert Raynes Wildlife Fund, Wyoming Governor's Big Game License Coalition, Wyoming Game and Fish Department (WGFD), and Bureau of Land Management. We hope to continue tagging and monitoring work in future years in other locations in Wyoming where significant nesting populations are known to occur because additional sample size is needed to identify the full range of wintering habitats used by Wyoming curlews and also to determine the patterns of migration and winter habitat use by curlews that breed in central and eastern Wyoming. We seek an ideal sample size of at least 20 total curlews in Wyoming, including at least five individuals from four or more different breeding populations. Importantly, these transmitters provide additional valuable data on adult survivorship and causes of mortality. This information will be used to inform regional conservation strategies that address both summer and winter habitat use areas, as well as migration routes and stop-over locations.

ACKNOWLEDGMENTS

We especially thank S. Patla (WGFD) for her enthusiasm and support for this project. We thank the many landowners that graciously and sometimes enthusiastically allowed us to study curlews on their lands. M. Brinkmeyer and K. Coates were dedicated field assistants on this project; we very much appreciate their ability to build relationships with local landowners while successfully studying a high density curlew population. Also, we want to thank the Meg and Bert Raynes Wildlife Fund for their initial support of curlew tracking in 2014 that helped to catalyze this larger effort. We also want to thank all the IBO staff for their valuable assistance with developing and executing this project, including H. Ware, G. Kaltenecker, R. Miller, J. Pollock, L. Urban, and B. Wright. L. Mojica and F. Smith of the Center for Conservation Biology of the College of William and Mary and the Virginia Commonwealth University provided invaluable assistance in all aspects, including choice of transmitters and establishing an Argos account for us, and F. Smith spent a week in Idaho to train us on transmitter attachment. C. Bykowsky, T. Rollins, and the staff at Microwave Telemetry have also been very helpful in providing help and advice on interpreting transmitter data.

LITERATURE CITED

Blake, S. A. 2013. Landscapes Used by Breeding Long-billed Curlew in the Columbia Basin. Thesis. Washington State University.

Buckland, S. T. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, Oxford; New York.

Cochran, J. F., and S. H. Anderson. 1987. Comparison of habitat attributes at sites of stable and declining long-billed curlew populations. Western North American Naturalist 47:459-466.

Cochran, J. F., and B. Oakleaf. 1982. Long-billed curlew survey evaluations with notes on distribution, abundance, and habitat use in Wyoming. Wyoming Game and Fish Department Nongame Program. API Project, Unpublished Report. Nongame Program, Lander, Wyoming.

Dugger, B. D., and K. M. Dugger. 2002. Long-billed curlew (*Numenius americanus*). *In* The Birds of North America, No. 628 (A. Poole and F. Gill, Editors.). The Birds of North America, Inc., Philadelphia, Pennsylvania. 28 pp.

Forcey, G. M., J. T. Anderson, F. K. Ammer, and R. Whitmore. 2006. Comparison of two double-observer point-count approaches for estimating breeding bird abundance. Journal of Wildlife Management 70:1674-1681.

Hartman, A. C., and L. W. Oring. 2009. Reproductive success of Long-billed Curlews (*Numenius americanus*) in northeastern Nevada hay fields. Auk 126:420-430.

Jenni, D. A., R. L. Redmond, and T. K. Bicak. 1982. Behavioral ecology and habitat relationships of Long-billed Curlew in western Idaho. Research Report. U.S. Bureau of Land Management. 234 pp.

Jones, S. L., T. R. Stanley, S. K. Skagen, and R. L. Redmond. 2003. Long-billed Curlew (*Numenius americanus*) Rangewide Survey and Monitoring Guidelines. US Fish and Wildlife Service, Denver, Colorado.

Liebezeit, J. R., P. A. Smith, R. B. Lanctot, H. Schekkerman, I. Tulp, S. J. Kendall, D. M. Tracy, R. J. Rodrigues, H. Meltofte, J. A. Robinson, C. Gratto-Trevor, B. J. Mccaffery, J. Morse, and S. W. Zack. 2007. Assessing the development of shorebird eggs using the flotation method: species-specific and generalized regression models. Condor 109:32-47.

Nichols, J. D., J. E. Hines, J. R. Sauer, F. W. Fallon, J. E. Fallon, and P. J. Heglund. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk 117:393-408.

Page, G. W., N. Warnock, T. L. Tibbitts, D. Jorgensen, C. A. Hartman, and L. E. Stenzel. 2014. Annual migratory patterns of Long-billed Curlews in the American West. Condor: Ornithological Applications 116:50-61.

Pollock, J., R. A. Miller, and J. D. Carlisle. 2014. 2014 Abundance and Productivity of Long-billed Curlews (*Numenius americanus)* in the Long-Billed Curlew Habitat Area of Critical Environmental Concern of Southwest Idaho. Unpublished report, Boise State University.

Redmond, R. L., and D. A. Jenni. 1986. Population Ecology of the Long-billed Curlew (*Numenius americanus*) in Western Idaho. Auk 103:755-767.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5-14.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 Supplement:120-138.

Table 1. Estimated density of Long-billed Curlews (*Numenius americanus*) at six Intermountain West breeding sites in 2015.

Site	Density Estimate	95% Confidence Interval	
	LBCU/km^2	Lower	Upper
ACEC, ID	0.719	0.469	1.104
Daniel, WY	6.781	5.189	8.861
Flat Ranch, ID	2.637	2.016	3.450
Pahsimeroi, ID	5.541	3.496	8.782
Cody, WY	0.774	0.478	1.254
MPG Ranch, MT	0.539	0.215	1.353

Table 2. Constant Daily Survival Rate (DSR) of Long-billed Curlew (*Numenius americanus*) nests in 2015 using the maximum likelihood version of the Mayfield model in Program Mark. Nests with unknown fates were removed from the analysis, as were nests found on or after hatch date.

Site	*n*	Constant Daily Survival Rate		95% Confidence Intervals	
		Estimate	Standard Error	Lower	Upper
ACEC, ID	26	0.943	0.012	0.912	0.963
Daniel, WY	25	0.973	0.007	0.954	0.984
Flat Ranch, ID	11	0.965	0.014	0.923	0.983
Pahsimeroi, ID	17	0.971	0.011	0.941	0.986
Cody, WY	3	1.000	0.000	1.000	1.000
MPG Ranch, MT	1	1.000	0.000	1.000	1.000

Table 3. Long-billed Curlew (*Numenius americanus*) nest survival compared with apparent hatch rate for the same set of nests. Nest survival was calculated by raising the constant Daily Survival Rate (DSR) to the power of 33, which is the number of days from onset of laying to hatch date. Apparent nest success (the number of nests that hatch divided by total number of nests) does not account for differences in nest exposure.

Site	*n*	Modeled Nest Success	*n*	Apparent Nest Success	
		Mayfield Estimate		# hatch	% hatch
ACEC, ID	25	14.44%	26	6	23.08%
Daniel, WY	26	40.40%	30	13	48.00%
Flat Ranch, ID	11	31.44%	11	5	45.45%
Pahsimeroi, ID	17	40.20%	18	11	58.82%
Cody, WY	3	100.00%	3	3	100.00%
MPG Ranch, MT	1	100.00%	1	1	100.00%

Table 4. Capture and nest fate details for Long-billed Curlews (*Numenius americanus*) trapped in Wyoming during the 2015 field season. Wyoming Game and Fish Department funded the transmitters attached to CN, ET, JC, and KC.

Site (Wyoming)	Alpha Flag	Capture Date	PTT	Sex	Nest Fate
Heart Mountain Ranch	CN	5/26/2015	Yes	F	Successful
Heart Mountain Ranch	EC	5/27/2015	No	F	Successful
Polecat Bench	CY	5/25/2015	Yes	F	Successful
Daniel	KC	6/2/2015	Yes	F	Successful
Daniel	EX	6/2/2015	No	F	Successful
Daniel	JC	6/2/2015	Yes	M	Abandoned
Pinedale	ET	6/2/2015	Yes	F	Depredated
Pinedale	HM	6/2/2015	No	F	Successful

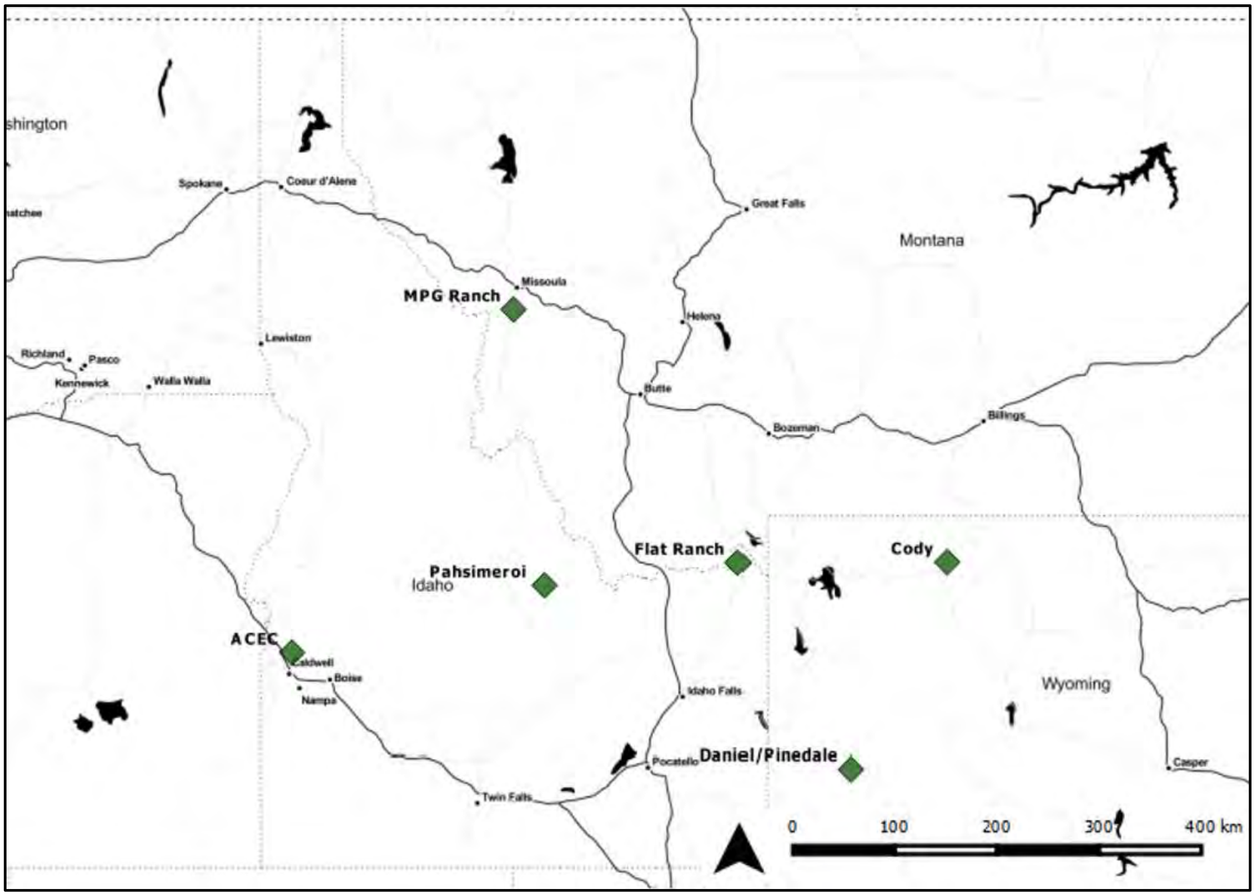

Figure 1. Overview map of Long-billed Curlew (*Numenius americanus*) reproductive success study sites in 2015.

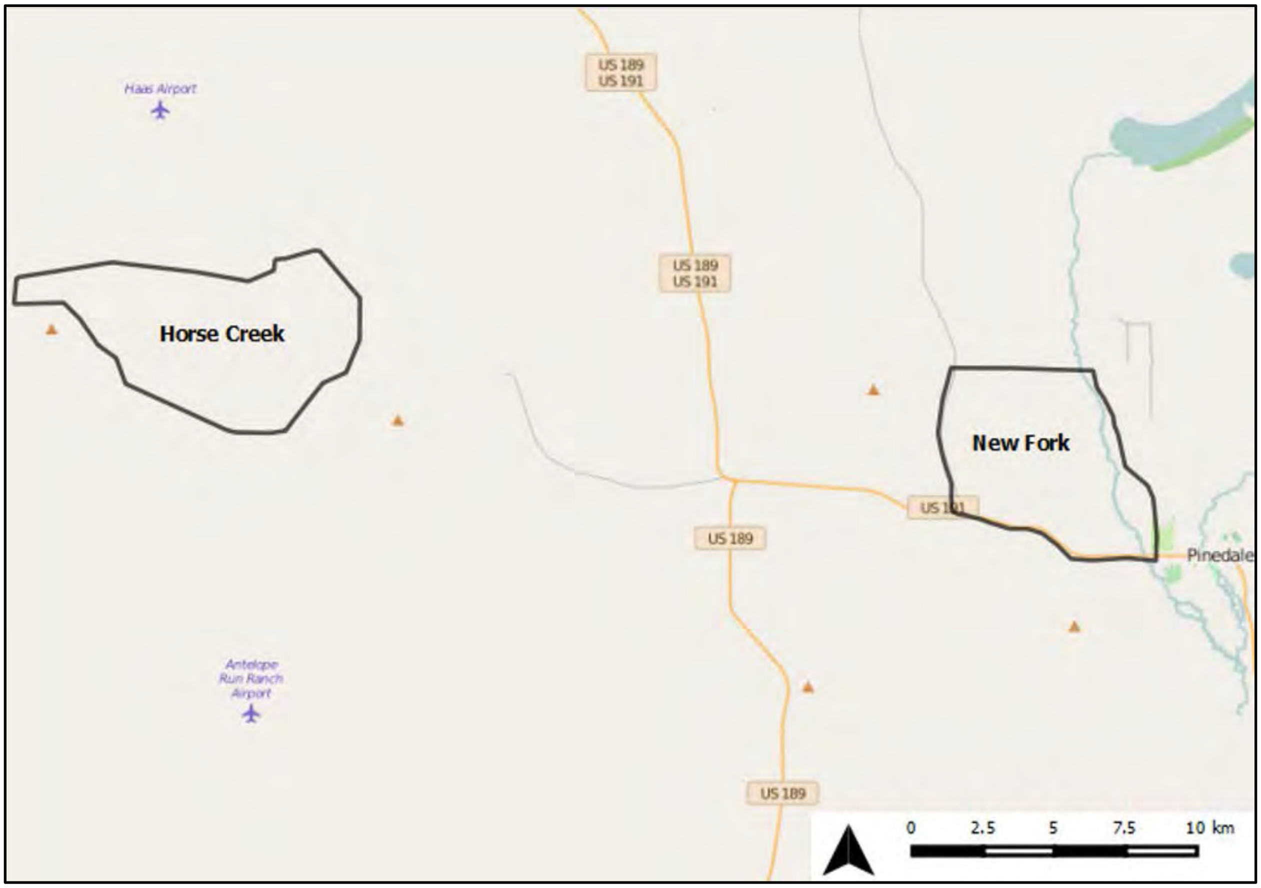

Figure 2. Focal Long-billed Curlew (*Numenius americanus*) study areas at the Daniel/Pinedale, Wyoming site in 2015. Boundaries are based on approximate study area boundaries of historic Long-billed Curlew research by Cochran and Anderson (1987).

Figure 3. A captured Long-billed Curlew (*Numenius americanus*) with a US Geological Survey aluminum band on the lower right leg and a green alpha flag ("CP") on the upper left leg.

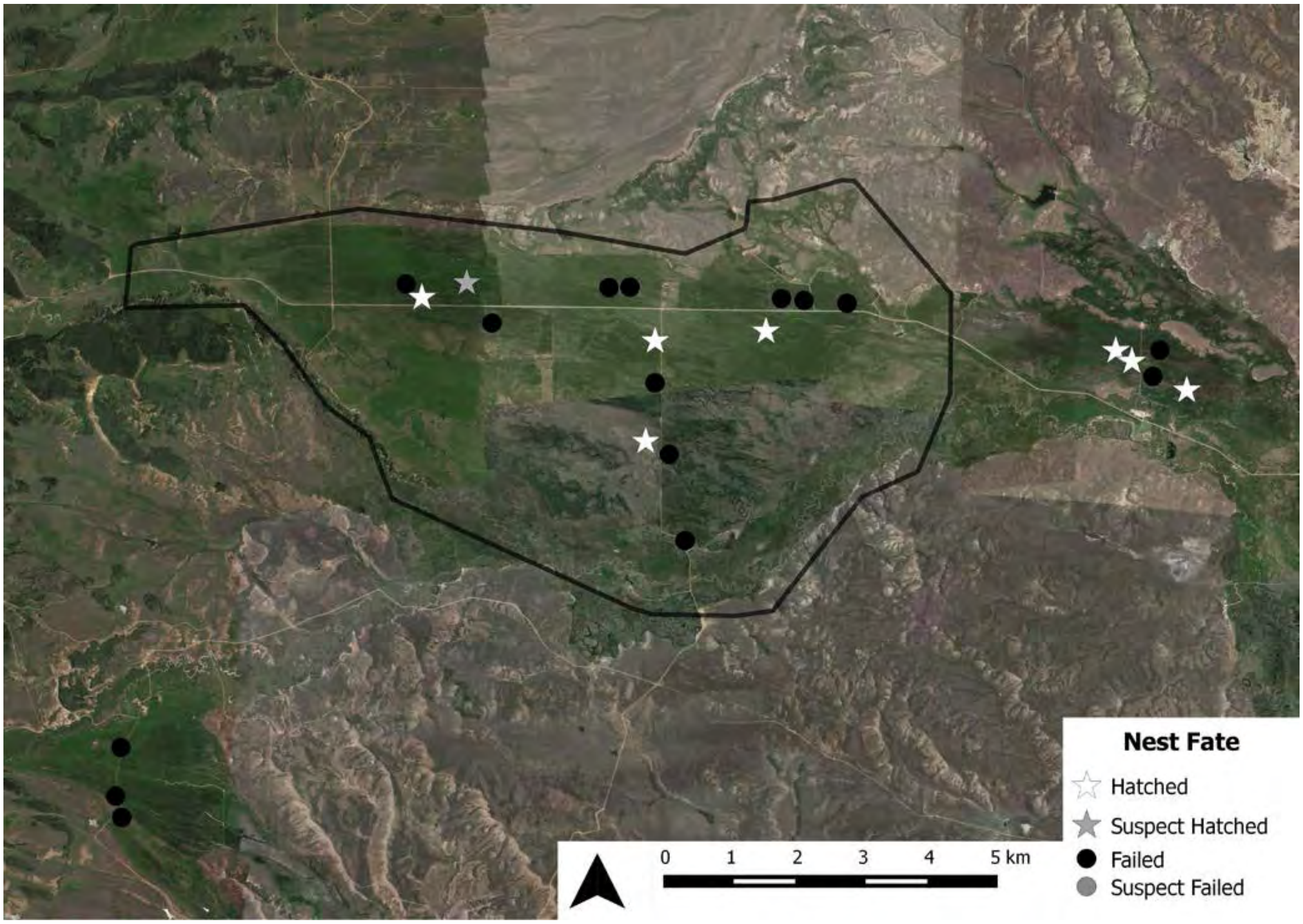

Figure 4. Long-billed Curlew (*Numenius americanus*) nests and their fate in the Horse Creek area of the Daniel/Pinedale, Wyoming study site during 2015. Nest searching was not restriced to the historic study area boundary (outlined in black).

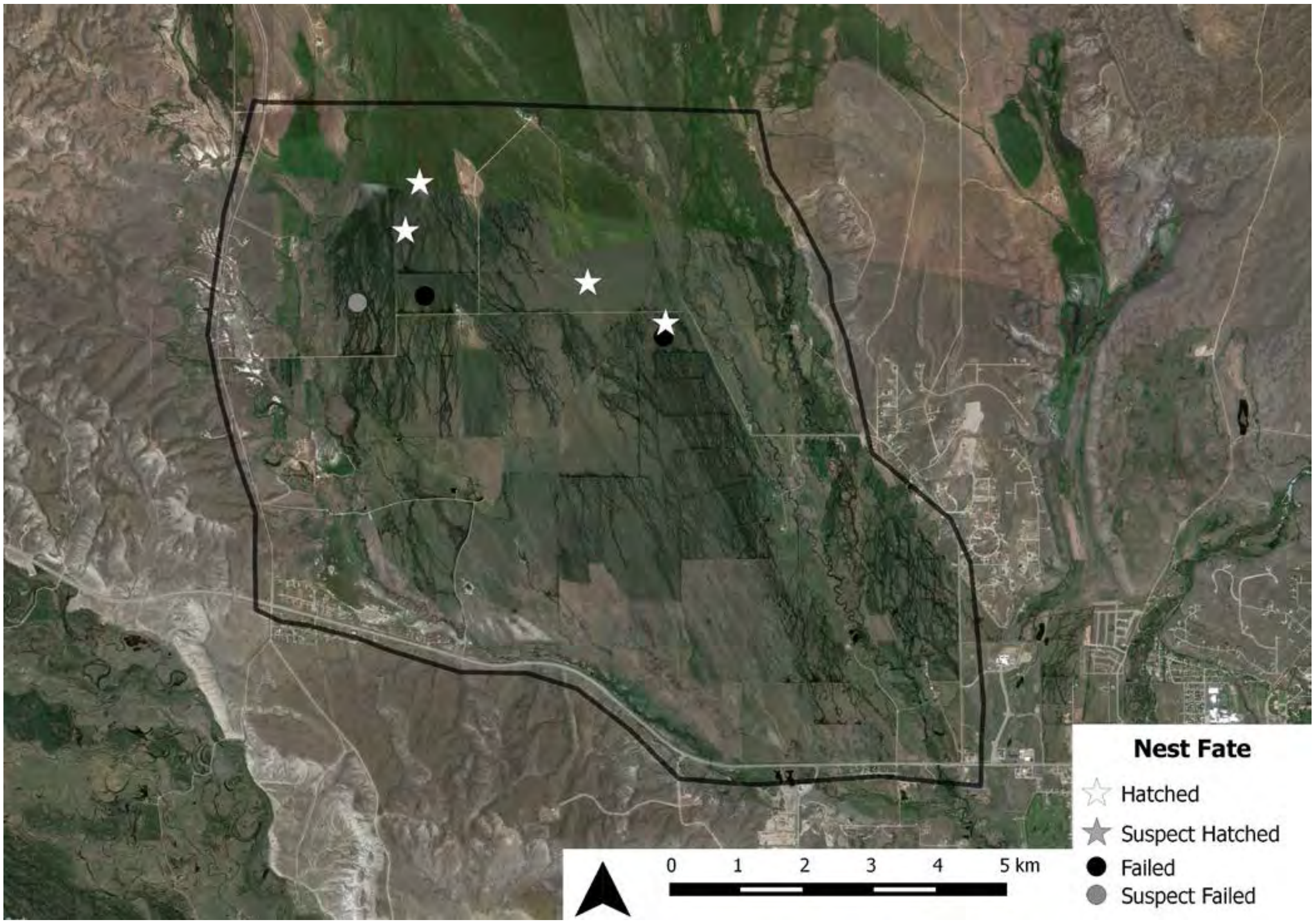

Figure 5. Long-billed Curlew (*Numenius americanus*) nests and their fate in the New Fork area of the Daniel/Pinedale, Wyoming study site during 2015. Pinedale, Wyoming lies to the southeast.

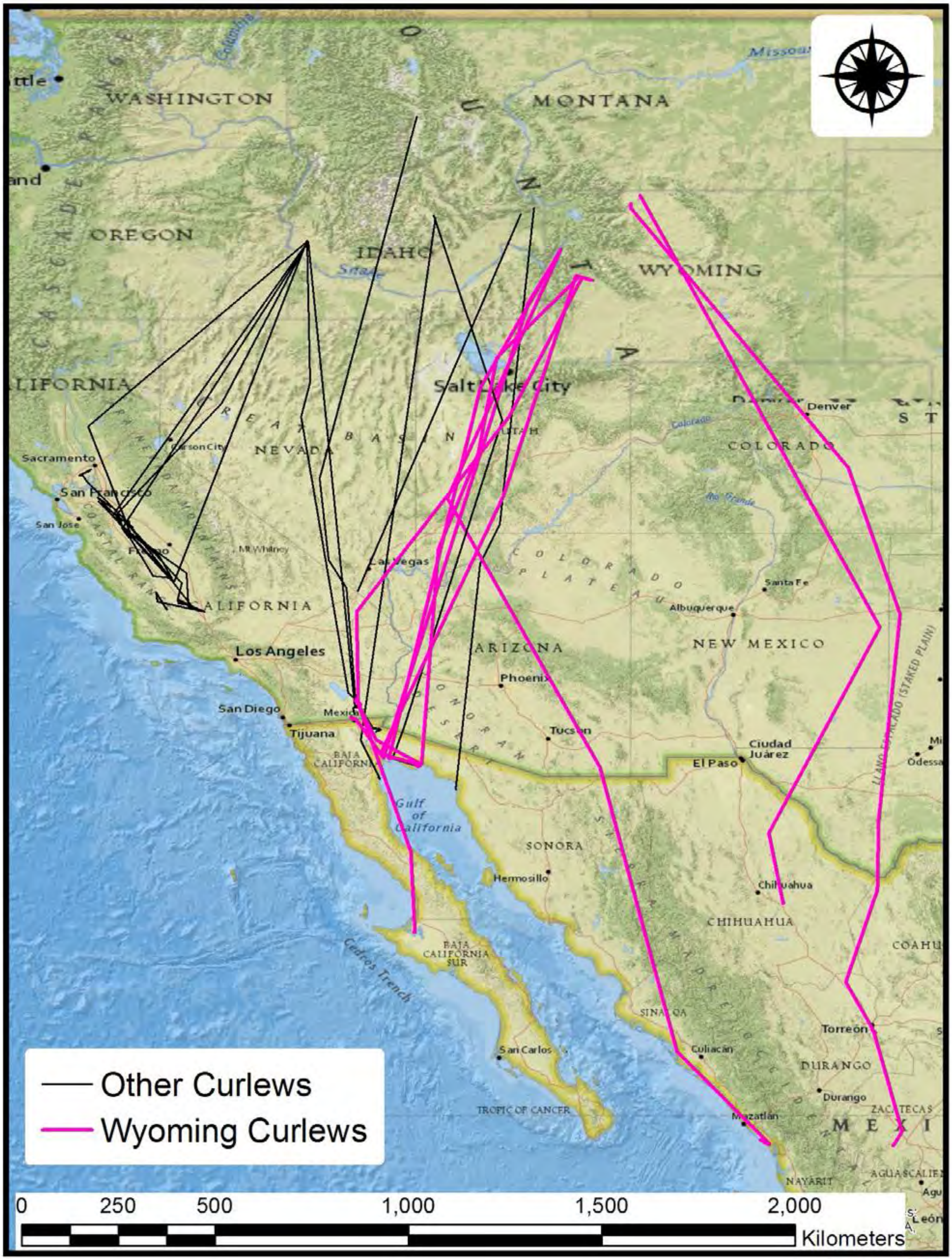

Figure 6. Summary map of migration routes and post-breeding destinations of Long-billed Curlews (*Numenius americanus*) tracked from Idaho, Montana, and Wyoming in the 2015 fall migration. Curlews tracked from Wyoming are shown in pink.

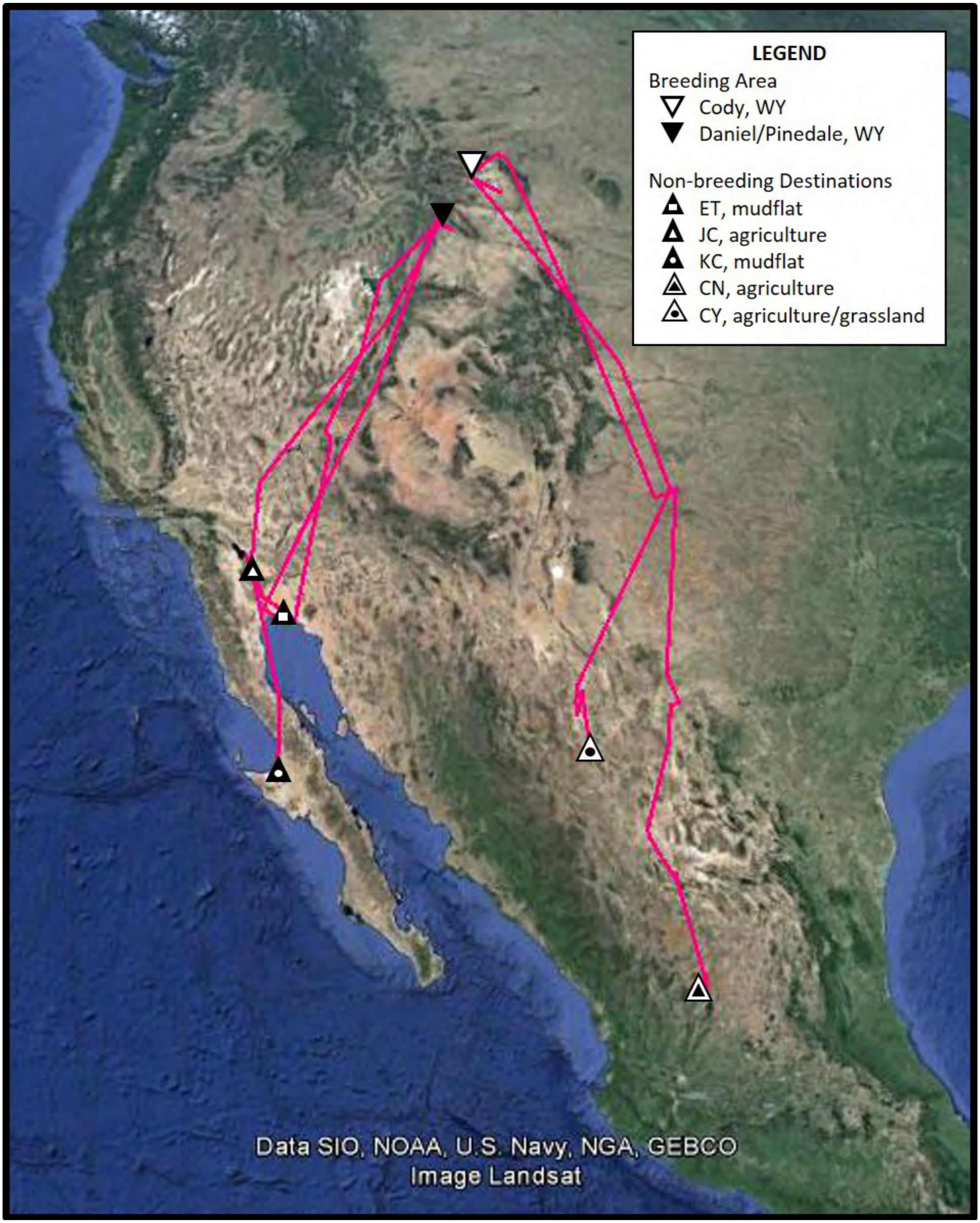

Figure 7. Summary of Long-billed Curlew (*Numenius americanus*) southbound migration from breeding areas near Cody and Daniel, Wyoming during the 2015 season.

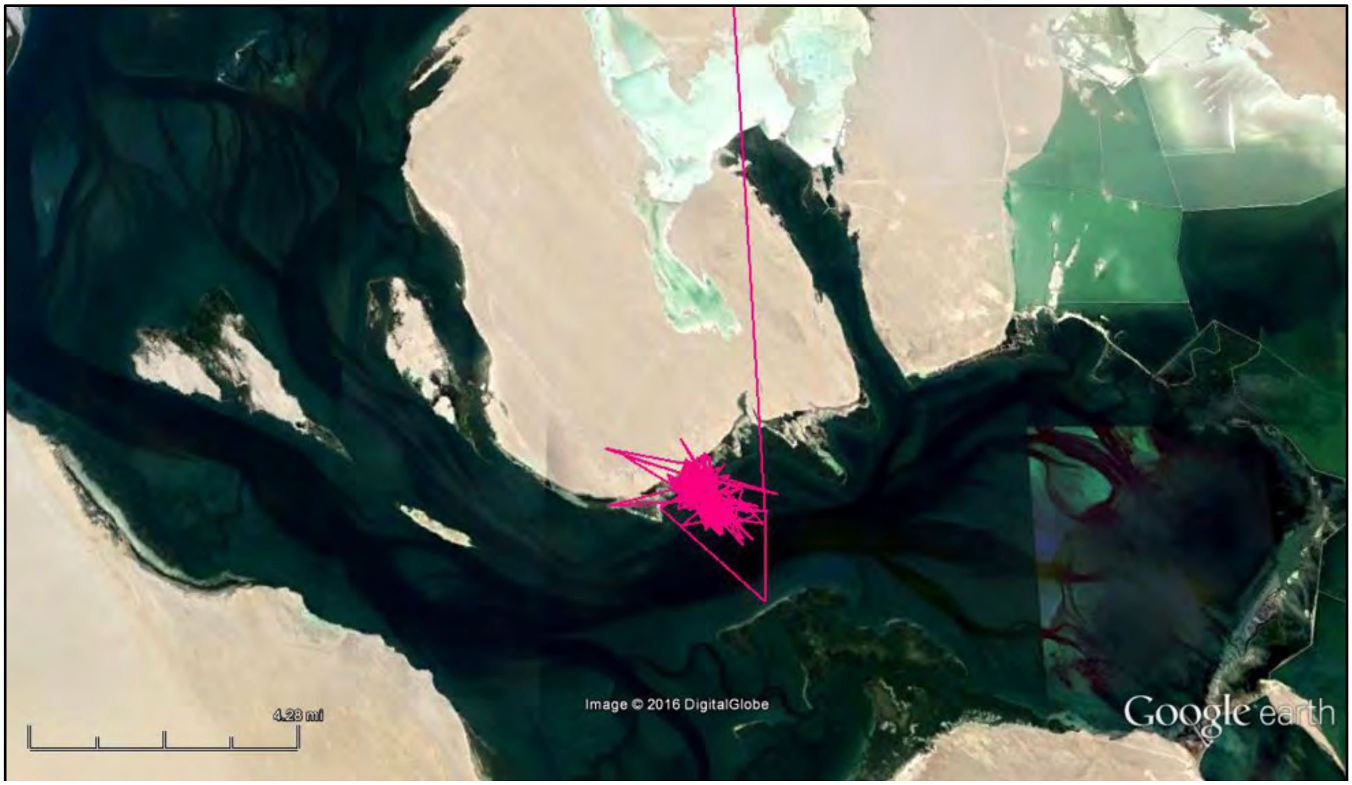

Figure 8. Post-breeding movements of "KC", a female Long-billed Curlew (*Numenius americanus*) captured in Daniel, Wyoming. After departing the breeding area on approximately 12 July 2015, she stopped in agricultural fields south of the Salton Sea in California for several weeks before settling at this location on a tidal mudflat on the west coast of the Baja California peninsula in Mexico. Another curlew (ET) equipped with a satellite transmitter in Daniel, Wyoming also migrated to a mudflat.

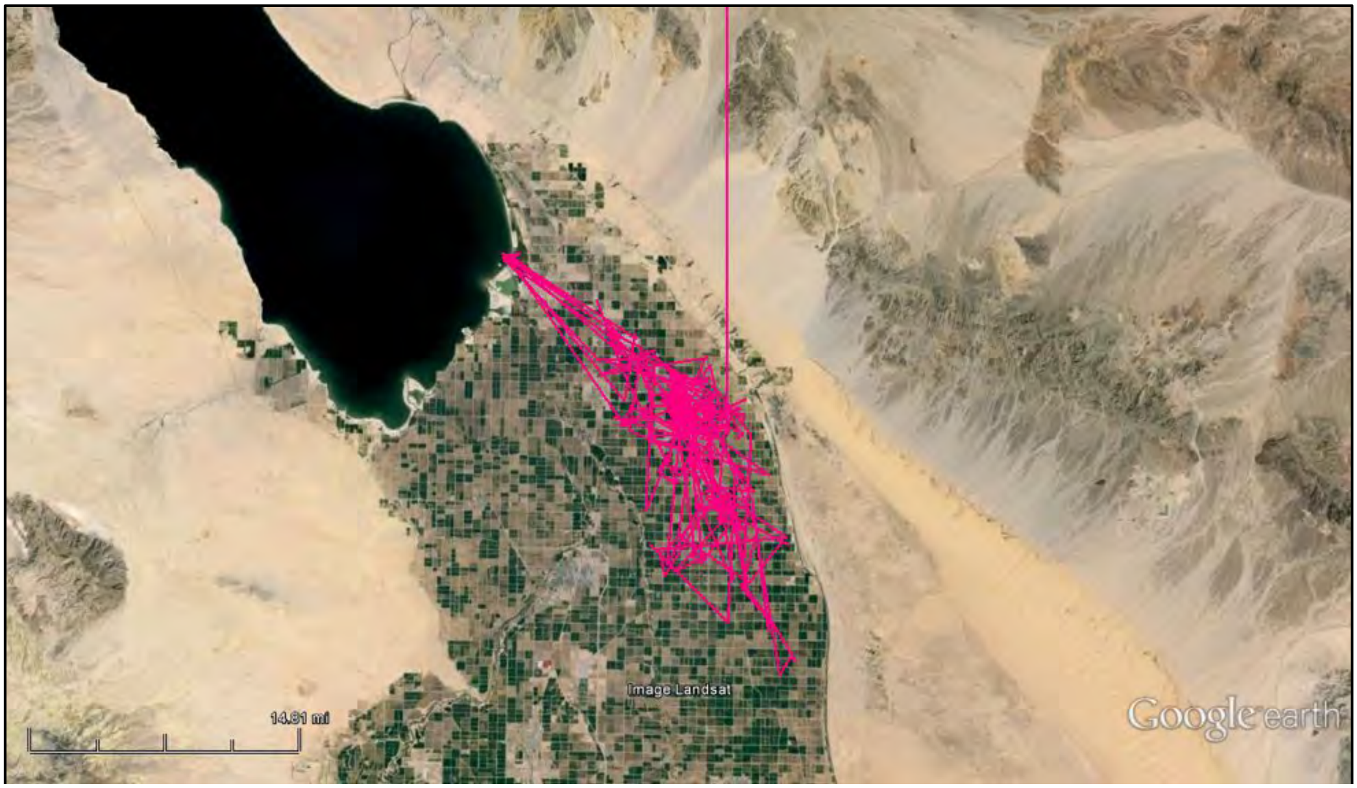

Figure 9. Movements of Long-billed Curlew (*Numenius americanus*) "JC" following migration from Daniel, Wyoming to the Imperial Valley near the Salton Sea in southern California. Travel among different agricultural fields leads to a more spatially dispersed pattern of foraging locations.

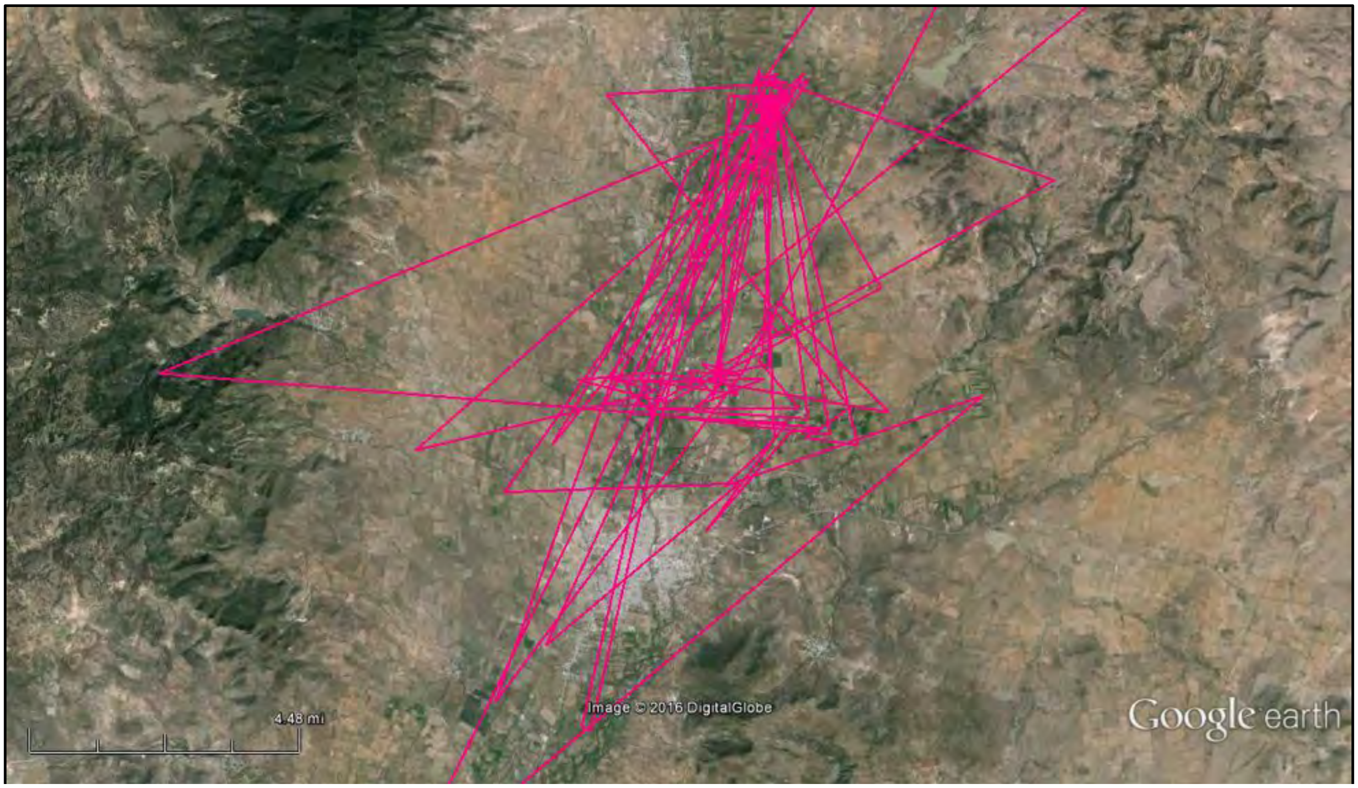

Figure 10. Movements of Long-billed Curlew (*Numenius americanus*) "CN" around agricultural fields in Chihuahua, Mexico during the non-breeding season. CN had a successful nesting season at Heart Mountain Ranch in Cody, Wyoming in 2015.

OCCUPANCY, NEST SUCCESS, AND HABITAT USE OF GREAT GRAY OWLS (*STRIX NEBULOSA*) IN WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Great Gray Owl

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: 1 January 2013 – 1 July 2015

PERIOD COVERED: 1 January 2013 – 1 July 2015

PREPARED BY: Bryan Bedrosian, Teton Raptor Center
Katherine Gura, Teton Raptor Center
Beth Mendelsohn, Teton Raptor Center

ABSTRACT

The Great Gray Owl (*Strix nebulosa*) is designated as a Species of Greatest Conservation Need in Wyoming due to limited and vulnerable habitat. In 2013, we initiated a multi-year study on Great Gray Owls in western Wyoming to understand seasonal habitat use, determine prey use, and develop habitat selection models for predicting seasonal habitats in western Wyoming. From 2013-2015, we conducted nighttime callback detection surveys for forest owls and estimated a total of 40 territories across 207 km^2 of effectively surveyed habitat. We documented 36 nesting attempts across years, with an average nesting density of one nest per 2.7km^2. Productivity has declined from previous estimates from this population to 1.7 fledglings per nest. Nests are typically located in old stick nests or snags. Nest success was lower in snag nests and in territories with fewer pocket gophers. Characteristics of habitat at nest sites and within breeding home ranges of marked owls compared to random plots included older-aged forests with higher canopy cover, further from roads, and on lower slopes. Owls moved towards riparian habitats during the winter months, and winter range was concentrated in the southern half of the Jackson Hole valley. We suggest that productivity may be limited by a combination of decreasing winter range and changing snow characteristics in western Wyoming. Further research is warranted on territory habitat use by breeding males to determine the importance of meadow habitats and relationship of productivity to long-term prey fluctuations. Understanding female condition prior to egg laying in relationship to prey populations, habitat conditions, and weather are necessary to better understand observed decreases in productivity. It appears that Great Gray Owls are regularly spaced within suitable habitat. Long-term studies are needed to investigate population trends and potential impacts of climate change. Potential decreases in productivity and limited critical winter range over time still warrant concern.

INTRODUCTION

The Great Gray Owl (*Strix nebulosa*) is classified as a Species of Greatest Conservation Need with a Native Species Status Unknown (Tier I) in Wyoming. Population status and trends for the Great Gray Owl are unknown but suspected to be stable, while habitat is restricted and vulnerable (WGFD 2010). Overall, there are little population and habitat data from western Wyoming. Franklin (1988) studied Great Gray Owls breeding ecology in eastern Idaho and western Wyoming in the early 1980s, and a follow-up nesting habitat study was conducted in the mid 1990s (Whitfield and Gaffney 1997). Anecdotal nesting data exist from other studies in Wyoming (e.g., Craighead and Craighead [1969], the USFS, and public reports), but no data exist on owl densities or movements in the Rocky Mountain region. Wyoming is the southernmost extent of this species' breeding range in the Rocky Mountains (Bull and Duncan 1993), athough recent reports of Great Gray Owls have been documented during the summer months in Utah (USFS, personal communication). The older-aged, boreal forest habitats associated with Great Gray Owls may be at risk from both natural and anthropogenic disturbances such as wildfire, disease outbreak, drought, climate change, logging, and development.

Boreal forest owls, such as the Great Gray Owl, are often difficult to study due to relatively low occurrence rates, difficult to access habitats, and secretive nesting behaviors. They remain one of the least researched raptor species in the U.S. The majority of studies employ passive methods of monitoring owls, such as occurrence and callback surveys. Previous studies in the US include a large demographic and movement study in northeastern Oregon from 1982-1988 (Bull and Henjum 1990), a 3-year study on breeding and nesting habitat in eastern Idaho and western Wyoming from 1980-1983 (Franklin 1988), a follow-up of the Franklin (1988) study from 1994-1996 (Whitfield and Gaffney 1997), and several projects on the isolated sub-species of Great Gray Owl in the Sierra Mountains of California. Two additional studies on Great Gray Owl movements from Canada incorporate small mammal abundance influences on movements and dispersal (Nero 1980, Duncan 1992). With the exception of one study that correlated owl population trends with clearcut logging and forest thinning (Whitfield and Gaffney 1997), no published studies have investigated changes in populations based on changing forest dynamics.

A distinct subspecies of the Great Gray Owl occurs in the Sierra Mountains of California (Hull et al. 2010). Many studies have been conducted on that discrete population. Sears (2006) modeled habitat suitability based on occurrence surveys of meadow complexes. van Ripper et al. (2013) investigated the influence of prey availability, forest structure, and anthropogenic disturbance, again based on occurrence sampling. Wu et al. (2015) conducted a retrospective study of nest site characteristics. Rognan et al. (2009) began utilizing automated recorders as a census method. van Ripper and Wagtendonk (2006) used radio-tagged locations from 12 owls in 1986-1990 to assess home range characteristics.

Great Gray Owls typically occupy older-aged Douglas-fir (*Psuedotsuga menziesii*) forest stands in the northwestern US, where neighboring owl nests can be located as close as 430 m (Bull et al. 1988a). Great Gray Owls in Idaho and Wyoming have also been associated with lodgepole pine (*Pinus contorta*) forests due to presence of raptor stick nests (Franklin 1988).

Great Gray Owls depend on forests with high canopy cover during the breeding season, which are suspected to increase fledgling survival (Whitefield and Gaffney 1997). During the winter months, some populations move to areas of lower elevation and snow cover (Bull et al. 1988, van Ripper and Wagtendonk 2006). Since Great Gray Owls do not build nests, they rely on existing structures for nesting, such as mistletoe (*Arceuthobium* spp.), broken snags, and stick nests constructed by other raptors and corvids (Bull and Henjum 1990, Duncan and Hayward 1994). In Wyoming during the early 1980s, Franklin (1988) found 60% of Great Gray Owl nests on broken snags, and 40% in old stick nests, typically built by Northern Goshawks (*Accipiter gentilis*; goshawk). Subsequent studies within that area suggested decreased snag nest use and an increased reliance on raptor nests (Whitfield and Gaffney 1997). A 6-year study of nesting Northern Goshawks on the Caribou-Targhee National Forest in the 1990s reported Great Gray Owls nesting in 8 of 27 goshawk territories; 17 of these alternate goshawk nests used by the owls were in Douglas fir and 1 was in an Englemann spruce (*Picea engelmannii*; Patla 1997). Great Gray Owls consistently avoided clear-cuts for nesting (Bull et al. 1988, Whitfield and Gaffney 1997, Fetz et al. 2003), but such areas may be important for foraging (Franklin 1988).

Prey abundance and availability drives movements (Duncan 1992) and occurrence (van Ripper et al. 2013) of owls and likely influences nesting demographics (Franklin 1988). Several analyses of Great Gray Owl pellets found a reliance on *Microtus* vole species (Oregon, Bull et al. 1989; Manitoba, Duncan 1992) and pocket gophers (Idaho, Franklin 1987; California, Winter 1986). The proportions of voles to pocket gophers in the diet is likely a function of relative density.

In 2013, we initiated a large-scale ecological study on Great Gray Owls in western Wyoming. The study area partially overlaps the previous studies of Franklin (1987) and Whitfield and Gaffney (1997), which included both sides of the Teton Mountain range, allowing for direct comparisons. Several groups collaborated on this study, including the Teton Raptor Center, Wyoming Game and Fish Department, Bridger-Teton National Forest, Grand Teton National Park, and Craighead Beringia South. We designed the placement of the main study area to correspond with planned forest treatments, in the interest of using these data for future inquiries into the effects of thinning and burning on owl movement and nesting ecology.

The main objectives of this study were to:

1. Understand nesting habitat for Great Gray Owls in northwest Wyoming.
2. Determine nesting density for Great Gray Owls.
3. Determine seasonal home ranges of adult and sub-adult Great Gray Owls.
4. Create a long-term framework for surveying small mammal populations.
5. Begin investigating how fluctuations in small mammal abundance relates to occupancy and productivity.
6. Create and validate a breeding season habitat suitability model.
7. Create a long-term monitoring framework for Great Gray Owl populations.

We supplemented the above with secondary concurrent objectives (as sample sizes of known territories allowed):

1. Determine if nest site availability limits the Great Gray Owl population.
2. Investigate the use of nest cameras for prey assessment.

3. Examine prey use through regurgitated pellets.

METHODS

Study Area

The primary study area for 2013-2015 included the base of the Teton Range and the Snake River riparian corridor from the areas around Moose, Wyoming in southern Grand Teton National Park, south to the Snake River Canyon. We expanded the study area in 2015 to include northern areas within Grand Teton National Park (e.g., Emma-Matilda/Two Oceans area) and Bridger-Teton National Forest (e.g., Rosie's Ridge and Blackrock areas). The typical forest habitats consisted of Douglas fir, lodgepole pine, sub-alpine fir (*Abies lasiocarpa*), and aspen (*Populus tremuloides*) surrounding the valley, and mixed cottonwood (*Populus* spp.), spruce (*Picea* spp.) forests within riparian areas. Both mesic and sagebrush (*Artemesia* spp.) meadows occurred throughout the study area. Housing subdivisions are common throughout the study area but rarely extend beyond 1.5 km from the valley floor.

Nesting Surveys

From 2013-2015, we conducted callback surveys across our study area to record the presence of Great Gray Owls during the courtship period of Great Gray Owls (mid-February-April). We followed the US Forest Service (USFS)-Bureau of Land Management protocol (Quintana-Coyer et al. 2004), with slight modifications as described below.

To determine callback survey locations, we used the existing Bridger-Teton National Forest (BTNF) habitat layer to delineate any forest stand (regardless of species) with an average diameter at breast height (DBH) of 25 cm or greater, because the average DBH of Great Gray Owl nest trees was 52.7 cm in previous studies (Franklin 1988). Within that layer, we placed survey points to completely cover the applicable habitat. Although Cramp (1985) asserts that Great Gray Owl calls are audible at distances up to 800 m, we conservatively adjusted our detection radius to 200 m. Therefore, survey locations were approximately 400 m apart. We began surveys no earlier than 0.5 hour after sunset, and typically completed before 0200 hours. Using a FOXPRO caller near maximum volume, we played calls for Great Gray Owls and Boreal Owls (*Aegolius funereus*). Each calling period consisted of a 2-minute listening period, followed by the Boreal Owl territorial call, a 1 minute listening period, the Great Gray Owl male territorial call, a 1 minute listening period, the Great Gray Owl male territorial call again, and a final 2-minute listening period. We also re-surveyed a proportion of the calling locations to help determine detectability. In 2015, we only re-surveyed within known Great Gray Owl nesting territories and at locations with Great Gray Owl detections in the first round. All known territories were surveyed at least twice during the call period.

We conducted backcountry surveys in pairs, typically on skis or snowshoes. We surveyed areas surrounding neighborhoods and roads singly, using vehicles. We also used snow machines on designated routes, when possible, and in teams of 2 for safety. All vehicles were turned off and surveyors did not move or talk during the survey period to maximize detectability.

When a Great Gray Owl was detected at a survey location, we did not survey neighboring locations to help ensure the owl(s) did not follow us. When Great Horned Owls were detected during the initial listening period at a survey location, we omitted the Boreal Owl call (this prevented eliciting a response from a Boreal Owl that could potentially increase predation risk by the Great Horned Owls). Similarly, if we detected a Boreal Owl, we omitted the Boreal Owl call at neighboring locations, but we still played the Great Gray Owl call.

In 2015, we created a preliminary resource selection model using re-locations from marked owls in 2013-2014, and used the model to help predict valuable survey locations in 2015. We also reduced total call locations by focusing on the interior of forest patches, which maximized survey areas.

We recorded all owl species detected, and estimated distance and direction of each owl. To help with distance estimates, we played owl calls at typical volumes for each species at known distances during training sessions. We also recorded type of call for all Great Gray Owls (e.g., male territorial, female contact, female agitated, exclamatory) and for other species, when possible. We noted the predominant tree species within the immediate area surrounding the survey location and average DBH of the stand. When wind speeds exceeded 16 km per hour or during significant precipitation events, we did not conduct surveys.

We examined callback data for patterns in owl responses, and removed all suspected records of the same owl (e.g., an owl was heard at successive survey points in the same general direction or followed the surveyors). We then categorized detections by species in 7 bins based on hour from 1900-0100 hours. Surveys rarely occurred prior to 1900 hours or after 0100 hours. We then calculated expected detections based on total surveys conducted in each bin. We used Chi-square tests to determine if detections were differed from expected.

Nest Searching and Monitoring

Following the night callback survey period, we searched for nests in all areas where Great Gray Owls were detected. We exhaustively searched all habitat patches for old stick nests, abnormal tree growths (hereafter witches brooms), and broken snags large enough for an owl nest. Any potential nesting structure was recorded and searched for signs of occupancy (e.g., an incubating bird, feathers, whitewash, or pellets). We also used the male contact call or begging call to regularly solicit calls from nesting owls, nestlings, and/or fledglings while nest-searching. To record search effort, we recorded all of our tracks every 10 m using a Garmin etrex20 or extrex10 GPS unit. This also helped us determine if particular areas were not adequately searched.

In all areas where we detected Great Gray Owls during the night callback surveys but did not locate an active nest, we also conducted fledgling callback surveys during July and August. For fledgling surveys, we covered the entirety of suitable nesting habitat, playing a mixture of contact and begging calls 400 m apart or less to solicit responses from fledgling owls. We also opportunistically used callbacks while traversing the study area conducting other tasks (i.e., nest platform set-up, small mammal trapping, etc.).

We considered a territory "active" only if we found direct evidence of breeding, such as an incubating female or fledglings. We considered a territory "occupied" if we documented multiple night detections or saw at least one adult owl multiple times but no active nest or fledglings were located. Once active nests were located, we checked on nesting status at least once every week to determine success and fledge dates. We considered fledged nests as successful, but could not dependably monitor post-fledging mortality since chicks were not radio-marked.

To estimate density of Great Gray Owls, we omitted the northern areas (Two Oceans, Blackrock, Rosie's Ridge) because these areas were first searched in 2015 and are not yet adequately surveyed for density estimates. After analyzing callback detections, we regularly detected Great Gray Owls up to 300 m, so we used 300 m as our detection radius for the density estimates. We buffered all nighttime call locations by 300 m to determine the total effective area surveyed. We then used the 30 m GAP vegetation layer to delineate only forested habitat within our effective calling perimeter, since Great Gray Owl nests occur within this habitat. We then clipped the total area surveyed to only forested habitat, thereby removing all habitats where owls could not nest (i.e., sagebrush, meadows, water, etc.) to estimate how much nesting habitat was surveyed. We used this effective call area to calculate territory density of Great Gray Owls. To determine the number of territories within the study area, we used all confirmed nests sites and locations of fledglings. We also estimated active, non-nesting territories using our night survey results when we detected a female detection and/or at least 3 male detections within 500 m of each other.

We could not effectively search all of the areas surveyed with callbacks for nests, so we estimated our effective search areas across all years to calculate nesting density. First, we combined all of our track data and reduced the dataset to 1 May – 31 August to correspond with the nesting season. We then buffered all track data by 100 m. We used a conservative estimate of 100 m for effective search area because we could generally see nests up to 50 m and hear females and juveniles up to 300 m away while nest searching. Because detectability of nests and juveniles was not 100%, we felt that the conservative estimate of 100 m best reflected the cumulative effective search proximity. We then clipped this total area to only forested habitats in which owls could nest and used that to determine our effective search area. We used this effective search area estimate divided by the total active nests (and fledgling locations) within the search area to determine nesting density.

Nesting Habitat

We measured habitat variables at nest sites at 2 scales: on-the-ground at the nest level and at a 30-m scale using remote sensing layers and a GIS. To directly measure variables, we followed Wu et al. (2015) and measured canopy cover, nest height, nest tree height, nest tree DBH, slope, aspect, and the deterioration of the nest tree. The type of nest fell in to 3 categories: broken snag, stick nest (built by another bird species), or mistletoe. We assigned a number from 1-5 for deterioration (Wu et al. 2015), which scaled from a live intact tree (1) to a broken-top rotting tree with most of the bark and branches gone (5). Tree height and nest height were measured with a laser rangefinder, standing on the same level as the tree with a clear view, and calculated later, accounting for the eye level of the observer. For the habitat characteristics immediately surrounding the nest, we measured the degree and aspect of the slope (if applicable) with a protractor and compass and the tree's position on the slope (top, middle, or bottom). We binned aspect measurements based on cardinal directions to assess general aspect of nest sites. Standing under the nest tree, we used a convex spherical densiometer for canopy cover assessment in the 4 cardinal directions, and calculated the mean for the nest location. From the nest location, we also determined the distance to the nearest meadow available for owls to hunt using the rangefinder, and if a meadow was not readily visible we located it using aerial photographs in a GIS. A meadow was defined as any opening with a minimum of approximately a 25-m radius.

We further characterized the nest plot based on a 50-m radius around the nest (Wu et al. 2015). In the plot, we visually determined the dominant tree species, followed by the 2nd most abundant tree species. We assessed the canopy cover at 4 random azimuths 25 m from the nest tree, and also at the nearest tree in each cardinal direction from the nest using a convex spherical densiometer.

We also assessed the slope, aspect, canopy cover, and distance to meadow for all nests using the 30-m 2011 National Land Cover Database (NLCD) in GIS.

Nesting Platforms

To assess whether nesting structures are limiting the breeding population of Great Gray Owls, we began installing nesting platforms in the study area in the fall of 2013 with support from 1% for the Tetons. Wooden nesting platforms were made following Bull and Henjum (1990) with the aid of local Boy Scout and Girl Scout troops as part of our community outreach and education program. We used a random design to assign locations to install the structures. First, we delineated the area in which we had adequately surveyed for nesting owls both by callback surveys and fledgling surveys, and could thereby accurately describe nesting density in 2013. We divided this area into 2 sections: a control area and a treatment area. The control area was defined so natural fluctuations in owl density could be compared with any changes in density as a result of increasing nesting substrate options in the treatment area. In the treatment area, we used a GAP habitat layer to identify any forest patch with >25-cm DBH to define potentially available nesting habitat. We then randomly projected points within this layer that were a ≥100 m from the nearest edge and ≥400 m from the nearest neighboring point. We projected 40, 60, and 100 points in this manner. We determined that 40 locations was inadequate, as several large forest tracts did not have any points, and the 100 location layer placed too many locations near the forest edge to abide by the 400 m inter-point distance rule. So, we chose 60 random points, which adequately covered the treatment area without missing any large forest tracts. When placing platforms, we chose a tree of the species representative of that forest tract, with ≥40 cm DBH, and with an adjacent tree in which we could place a motion/thermal-triggered trail camera to monitor the platform for use. We chose the tree nearest to the random location that met this criterion. When tree height permitted, we installed all platforms 10.6 m above ground level. We also placed 1 remote camera near each of the platforms. Test cameras were deployed at our offices to monitor battery life of the units, and batteries were replaced as necessary.

Remote Nest Monitoring

Beginning in 2014, we placed remote still-cameras at known nest sites to determine if they could be used to determine prey delivery rates and prey composition between nests and years. Cameras were typically situated in an adjacent tree, with the exception of a camera that was placed above the nest due to a lack of nearby trees. We continued camera placement in 2015 on the same nests monitored in 2014.

Prey Surveys

We opportunistically located regurgitated pellets while conducting all forms of surveys. Each pellet was collected, labeled with date and location, and stored for later analysis. If no Great Gray Owls were detected in the immediate vicinity of a pellet location during the study, we did not assign a species to the pellet. However, if Great Gray Owls were regularly within the area in which a pellet was found or if the pellet was within 150 m of a known nest, we assigned that species to it for later analysis. We searched areas below and directly surrounding nest sites and associated roosting locations to collect pellets from nesting pairs and nestlings. Female owls typically leave the nest to regurgitate pellets and sometimes use the same location, often within 100 m of a nest site.

Prey items were identified using skeletal remains in the pellets. We separated skulls and mandibles from pellet matter using forceps, dissecting needle, and water (Marti et al. 2007). We identified prey to species when possible, including northern pocket gopher (*Thomomys talpoides*), red squirrel (*Tamiasciurus hudsonicus*), northern flying squirrel (*Glaucomys sabrinus*), and long-tailed weasel (*Mustela frenata*). We combined species from the genera *Myodes*, *Microtus*, and *Phenacomys* combined into a “vole” category, *Peromyscus* and *Zapus* combined into a “mice” category, and *Tamius* species into a “chipmunk” category. We used tooth type and mandibular tooth-row length for the majority of identification to genera (Chomko 1990). For intact specimens of rodents, shrews, and weasels, we measured greatest skull length and mandible length (Elbroch 2006) to help identify species. We calculated total number of prey items identified, percentage of the diet by frequency, and percentage of diet by biomass. To estimate biomass, we used average species weights from Franklin (1989).

We conducted mark-recapture small mammal trapping at a sub-sample of known and suspected nesting territories during August and September each year. We selected 1 meadow site as close to the nest as possible and 1 forest site that was representative of the forest type near the nest. We used a 50-m square grid, placing 25 traps at a 10-m interval in each site. Over a 72-hour period, we checked traps at dawn and dusk. We made an effort to identify captured animals to species, noted sex and weight, and individually color marked them using non-toxic markers (Pauli et al. 2004). We calculated populations for different groups (chipmunks, mice, and voles) with Lincoln-Peterson estimates using the Chapman’s modification of the estimation of animal abundance and related parameters (Seber 1982).

We surveyed for pocket gopher abundance following van Ripper et al. (2013). We digitized all meadows within 500 m of known nests and randomly selected 3 (when available) for surveys. We started at the head of each meadow and walked 45-degree diagonal transects back and forth until reaching the end of the meadow, tallying fresh and old gopher mound visible within 10 m of the transect. Because we were interested in relative abundance between years and among territories, we annually tallied total survey length for each territory and divided by the number of fresh mounds to create an index of gopher abundance.

Tagging and Tracking

We captured Great Gray Owls and outfitted them with a VHF transmitter, a store-on-board GPS transmitter, or a remote-downloadable GPS data-logger with affixed VHF transmitter. We mainly used backpack-style attachments (GPS and VHF) and 1 tail mount attachment (VHF). We originally designed this project to utilize solar-powered satellite GPS transmitters, but did not pursue that option after speaking with the manufacturers and other researchers utilizing solar-powered transmitters on owls, because feathers cover the solar panels. We custom-made store-on-board and remote-download data-loggers for this study that were pre-set to gather GPS locations once or twice daily for approximately 6 months. VHF transmitters (Advanced Telemetry Systems and Holohil Systems, Ltd.) had a typical lifespan of approximately 2 years. Backpack-style transmitters weighed less than 3% of the owl's body mass (18-22 g) and the tail mount transmitter weighed 6 g. We fit GPS units on females only due to the greater mass of both the transmitters (30 g) and the females (range 1,210-1,550 g).

We used bal-chatri traps, bow-nets (Bloom et al. 2007), hand nets, pan traps, and mist nets with mice, sparrows, gerbils, or a raven decoy to capture owls. Trapping with prey baited traps occurred year-round, and the raven decoy was only used for difficult recaptures post-fledging (Bull and Henjum 1988). Fledglings captures took place in 2015 within 1 week of fledging using a net on an extendable pole and were leg tagged only (no transmitters) because of their small size at fledging. We banded owls with a US Geological Survey (USGS) and custom-made blue, yellow, and orange plastic alphanumeric leg flags. We used blue bands on all adults, yellow leg bands on the 2014 cohort, and orange on the 2015 cohort.

For all marked owls, we took standard ornithological measurements of each individual and collected a blood sample for later genetic analysis. Sex was determined using a small portion of the blood sample (Zoogen DNA Services, Davis, California) and age was determined based on molt (Suopajarvi and Suopajarvi 1994).

We attempted to relocate each marked owl ≥1 time weekly throughout the study. We recorded relocations obtained via homing techniques within 30 m of the owl without disturbing it. GPS data were gathered from transmitters either remotely via a wireless connection with a laptop or by recapturing the owl and removing the transmitter. We did not replace any removed GPS transmitter due to the difficulty of recaptures. If marked owls could not be located, we searched the entire study area on foot, by vehicles, and via fixed-winged aircraft when possible.

Habitat Use

We created both minimum convex polygons (MCP) and kernel density estimates (KDE) for each owl using ArcMap 10.3 (ESRI, Redlands, California) and geospatial modeling environment (GME; Beyer 2004). We calculated MCPs and KDEs for annual ranges, summer ranges (1 May – 31 August), and winter ranges (1 December – 31 January) for individuals. We removed all locations from incubating females when they were on the nest prior to analysis. If individuals had the same nesting status in consecutive years, we pooled the data. We used 1 December – 31 January to represent winter range because we were interested in owl movements during the period of deepest snow depths across the study area. We compared age, sex, and breeding status for differences in MCPs and KDEs.

We used the NLCD 2011 land cover product accessed from www.mrlc.gov to extract land cover use within the KDEs to estimate land use by breeding owls and for owl winter range. We created 50%, 75%, 90%, and 95% KDE estimates for all owls during the summer, as well as winter. Using mean inter-nest distance and general knowledge of regular owl movements, we determined that 75% KDEs were the most appropriate measure of territory size of actively breeding owls. We re-classified the NLCD into 7 categories of land cover; conifer forest, deciduous forest, riparian forest, meadows, developed, agriculture, and water/ice/rock, and extracted the percentage of land cover types within the 75% KDE for actively breeding owls during the summer to estimate land cover within active territories.

We extracted the same reclassified land cover types within the 75% KDEs for owls with GPS transmitters during the winter. Low sample sizes from VHF marked birds in the winter because of the restricted time period precluded the creation of individual KDEs for VHF marked owls. Therefore, we created a population level winter KDE using VHF marked owls and extracted land cover percentages within that KDE for comparison.

Habitat Modeling

Habitat modeling was completed with the help of Matt Hayes from Lone Pine Analytics, LLC. We investigated several covariates to include in a resource selection model to predict breeding and winter habitat, including land cover type, elevation, slope, aspect, distance to roads, distance to meadows, total vegetation height (as a proxy for stand age), and canopy cover. All raster covariates were re-sampled to 30 m and projected in UTM Zone 12T NAD 83. Elevation was measured and slope and aspect were calculated from a 30-m digital elevation model created by USGS and accessed from the Natural Resources Conservation Service Data Gateway web service (https://gdg.sc.egov.usda.gov/). Aspect was transformed into a TRASP (transformation of aspect) index, which is a circular transformation where a value of 0 are areas on north/northeast slopes (coolest and wettest orientation in northern latitudes) and a values of 1 on southerly slopes (Roberts and Cooper 1989). A distance to road layer was created from a statewide Wyoming Department of Transportation road shapefile, which included numbered USFS roads. This layer shows the distance to the nearest road for the center of each 30-m cell. Land cover was reclassified, several ways, using the NLCD layer. Distance to meadow was created by reclassifying the NLCD land cover data into a meadow/no meadow classification and calculating the shortest distance for each cell to a cell of the reclassified meadow. We reclassified the NLCD at 2 scales based on biological relevance to owls. First, we reclassified the NLCD into 7 categories as described above and second; we created a forest/no forest layer. Vegetation height and percent of tree canopy cover were both taken from the Landfire data products accessed at http://landfire.cr.usgs.gov/. These metrics provide a measure of the height of vegetation in a pixel as well as the percent of the canopy which is from trees.

We created breeding habitat models, using the actual used relocations from all ≥2-year-old owls from 1 May – August 31, excluding any relocations of incubating females (all points were combined, forming a population level model). We created a set of "available" points to compare with owl relocation points (i.e., "used" points). To create the available points, we randomly selected 5 times the number of used points in a 25-km buffer outside of the 75% KDE created from the known used points. This insured that we were not sampling available points within our KDE. After running the global model, we ran all possible combinations of that model because it is realistic that any subset of that model would be biologically relevant and meaningful. We ranked the models using AIC*c* and used the top model as our best model. We calculated odds ratios and coefficients from this final model.

We also created models of winter habitat. Because we were interested in assessing winter habitat during peak snow depths, we reduced the total relocation dataset to 15 December – 31 January, which resulted in a relatively small sample size. Because we had too few "Used" locations during this time period, we created 90% KDE home ranges for winter range using all owls to create a population level model. Used points were sampled randomly within this KDE and available points were, again, sampled within a 25-km buffer around the KDE at a ratio of 1:5 for used:available. We ran all possible model permutations because it is realistic that any subset of that model would be biologically relevant and meaningful. We ranked the models using AIC*c* and used the top model as our best model. We calculated odds ratios and coefficients from this final model.

For all models we ran a 10-fold cross validation and reported the cross validation error. Final models for both seasons were predicted spatially at a resolution of 30 m for use in subsequent work and publications. All data were processed in Program *R* (*R* Core Team 2015) utilizing various packages. All models were binomial logistic regressions.

Great Gray Owls typically need large stands of contiguous, suitable habitat. Modeling habitats creates an index of habitat "value" for each 30-m cell but, unless there is sufficient habitat surrounding that cell, then the habitat is not actually available for nesting. We created a measure to help account for this. We created a layer using, conservatively, the top 10% of the predictive breeding model and eliminated any areas not within the top predicted 10%. We then calculated the number of cells within a 500-m radius that also occurred within the top 10% of the model. Each cell then had a value of all the cells within a typical owl territory size with predicted habitat with a maximum of 901 cells. We binned the resulting layer into quartiles, removed any cells with less than 25% suitable habitat within 500 m, and created a predictive layer incorporating patch size.

RESULTS

Callback Surveys

We surveyed 558 individual locations in 2013 for nighttime callback detections, re-surveyed 158 of those locations once, and resurveyed 8 twice, for a total of 724 surveys. In 2014, we surveyed 557 unique locations, and re-surveyed 186 of those once and 31 twice. In

2015, we surveyed 337 locations and re-surveyed 72 of those once. It appeared that Great Gray Owls reduced calling towards the last few days of the survey period in 2013 (13 March – 26 April), so we altered the calling period to 18 February – 14 April in 2014. However, we did not detect the first calling Great Gray Owl until 3 March 2014, so we again altered the calling period to begin 3 March and ceased surveys 9 April in 2015 due to a sharp decline in detections that week.

Because there were multiple survey crews out each night, we had a total of 101 survey nights in 2013, 77 survey nights in 2014, and 53 survey nights in 2015. Total time spent surveying was 272 hours and 1 minute in 2013, 286 hours and 12 minutes in 2014, and 183 hours and 57 minutes in 2015. Using a 300-m detection radius, we surveyed a total of 120.8, 112.6, and 77.8 km^2 in each year from 2013-2015, respectively. Combined, we surveyed a total of 207 km^2 of forested habitat (Figure 1).

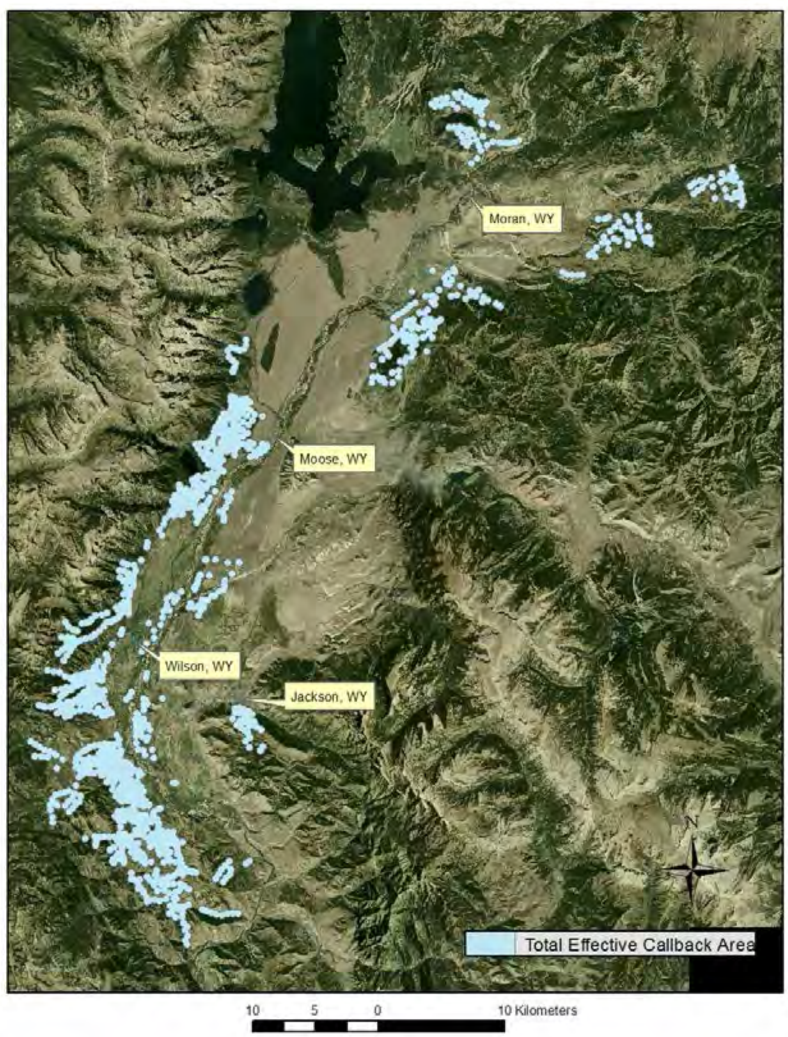

Figure 1. Total area effectively surveyed for forest owls in Jackson Hole, Wyoming (2013-2015) using nighttime callback technique and a 300-m detection radius.

To tally total number of detections, we first removed all possible duplicate detections of the same individual from the data by examining both field notes and mapped calling locations. After removal of those data, we tallied a total of 288, 129, and 263 individual owl detections from 7 species in 2013-2015, respectively (Figure 2). By year, we encountered an average of 2.96, 2.43, and 4.96 owls per survey night from 2013-2015, respectively. By time, we encountered 1 owl every 56.7, 133.1, and 42.0 minutes in 2013-2015, respectively. The owl species encountered most frequently across years was Great Horned Owl (n = 217), followed by Great Gray Owl (n = 159), Boreal Owl (n = 124), Northern Saw-whet Owl (*Aegolius acadicus*; n = 121), Northern Pygmy-Owl (*Glaucidium gnoma*; n = 24), Long-eared Owl (*Asio otis*; n = 13), and Barred Owl (*Strix varia*; n = 2).

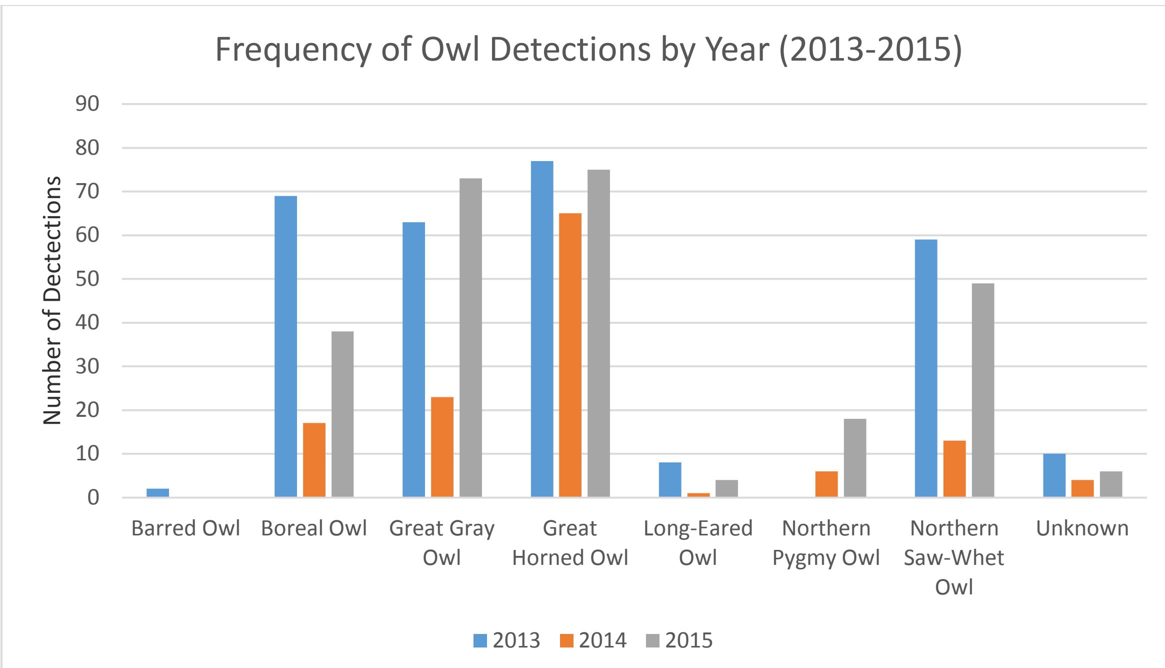

Figure 2. Frequency of owl detections in Jackson Hole, Wyoming by year and species.

We had significantly fewer Great Gray Owl detections in 2014 (average = 4.2 detections per week) compared to both 2013 and 2015 (15.8 and 14.2 detections per week, respectively; p = 0.017). Snowpack in 2014 was also significantly greater in 2014 than 2013 or 2015 ($p < 0.001$; Figure 3). During the survey period, average snowpack at the Phillips Ridge Snotel site was 1.61 m in 2013, 2.59 m in 2014, and 1.41 m in 2015 (USDA 2015). We detected 35 Great Gray Owl territories across years using a minimum of 3 male detections and/or 1 female detection within 500 m of each other.

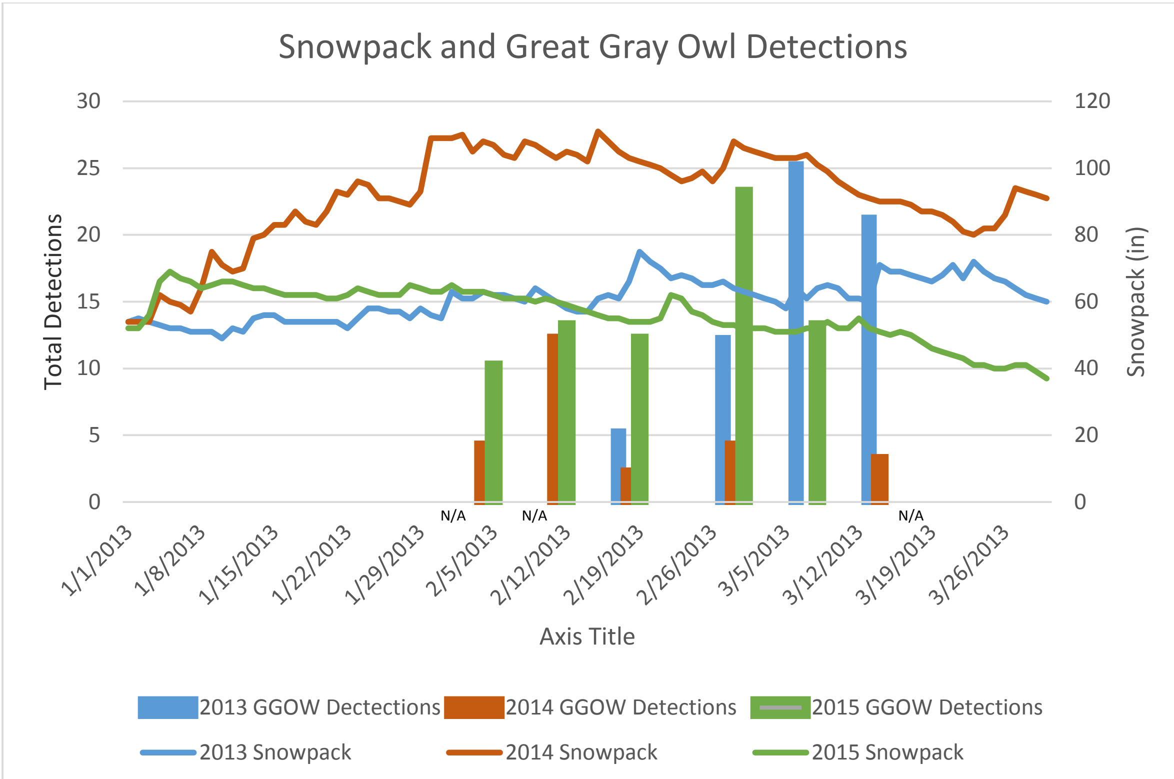

Figure 3. Frequency of Great Gray Owl detections by week and daily snowpack levels within the study area.

Callback Timing

We found that Great Gray Owl and Northern Saw-whet Owl detections did not differ from expected over the course of the evening (measured between 1900 and 0200 hours). Boreal Owls, however, called more than expected during the early evening ($p = 0.019$) and Great Horned Owls had higher call rates earlier and later in the evening with a lull from 2100-2300 hours ($p = 0.032$; Figure 4). There was large variation in number and timing of detections among years for Great Gray Owls (Figures 2 and 3). We detected many more Great Gray Owls in 2013 ($n = 63$) and 2015 ($n = 73$) when compared with 2014 ($n = 25$). Detections peaked in early April in 2013, mid-March in 2014, and were fairly constant from March-mid-April in 2015. In all years, there were few detections prior to March or after mid-April.

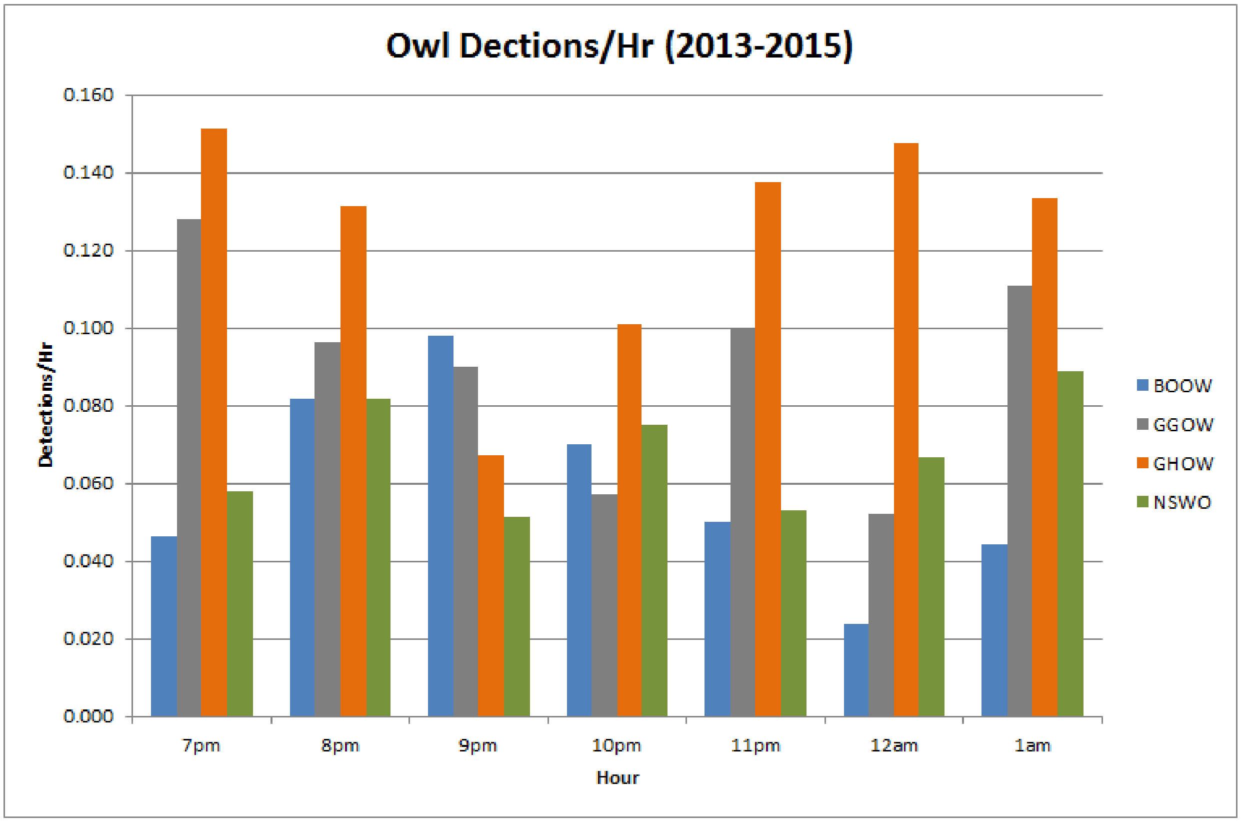

Figure 4. Hourly detection frequency of forest owls in Jackson Hole, Wyoming, 2013-2015.

Detectability

To begin estimating Great Gray Owl callback detectability, we retrospectively examined how often owls were detected within known and estimated territories (based on callback criterion). Within all territories, we detected owls on the first survey round in 73, 20, and 50% of known territories in 2013-2015, respectively. Within territories that were surveyed twice, we increased detection rates to 91, 31, and 82%, respectively. Restricting the analysis to only active territories (those with confirmed nests), we detected owls in 67, 22, and 47% of territories during our first survey and 67, 44, and 80% using multiple surveys, respectively, across years.

Nesting Demographics

To calculate nesting density, the effective search areas must be known. For raptor species, standardized nest search efforts are not cost-effective and are not typically used. Therefore, we used our best efforts to record all of our tracks while in the field to determine the effective search area. We first reduced all track data to the nesting season (1 May – 31 August) when we were actively searching for nests and fledglings. We then buffered each track location by 100 m. We dissolved the buffer boundaries and calculated the effective search areas by year, similar to the effective calling areas for nighttime detections. We effectively searched a total of 30.2, 63.9, and 30.6 km^2 in 2013-2015, respectively. Cumulatively, we searched a total of 88.1 km^2 over the 3-year study period.

We found a total of 36 confirmed nests across 3 years. We also had 4 instances (2013 = 1, 2014 = 1, 2015 = 2) where we found fledgling Great Gray Owls but did not locate the nest. Including the instances when fledglings were located, we found 4 active territories in 2013, 9 in 2014, and 24 in 2015. Nest success was 75%, 78%, and 83% in 2013-2015, respectively. Average fledging success was 1.5, 1.6, and 1.9 fledglings per nest across years, respectively. Incubation was initiated as early as 7 April, and the latest we observed females incubating was 11 June. Average fledge dates were 18 June, 27 June, and 13 June for 2013-2015, respectively.

Nesting Habitat

We found the majority of nests in lodgepole pine ($n = 8$), followed by Douglas fir ($n = 5$), subalpine fir ($n = 5$), aspen ($n = 3$), spruce spp. ($n = 2$), and narrow-leaf cottonwood ($n = 1$). Ten nest sites were located in old stick nests, 10 in broken trees (snags), 3 in growths caused by mistletoe, and 1 in an artificial nesting platform. All nests but 3 were located in the low to mid-elevation coniferous forests surrounding the valley floor. The exceptions were 3 nests located within the Snake River riparian area.

We measured nesting habitat, both on the ground and via remote sensing. Using direct measurements at 17 of our 23 active nest sites, nest heights ranged from approximately 1.5-18 m, and nests in snags were significantly lower in than other nests ($p < 0.001$). Mean slope of nests was 9.7 degrees (range 4-22) and most were located on a north-northwest aspect. Average canopy cover at the nest was 72.9% and did not vary between snag and stick/mistletoe nests. Average DBH of snag nest trees (74 cm) was greater than the average DBH of stick/mistletoe nest trees (36 cm; $p = 0.017$). We also measured the level of deterioration of nest trees on a scale of 1-5 (Wu et al. 2015), and found that snags had an average level of 4.2, while stick/mistletoe trees had an average level of 1.3. We found no difference between the canopy cover at nest sites and the average canopy cover within 50 m of the nest. Based on meadow criterion as defined by Wu (2015), we measured a mean distance from nest to meadow of 49 m (range 0-148).

We used the 2011 30-m NLCD to measure canopy cover and distance-to-edge for all nests. Because riparian habitat differs from the mixed coniferous forests surrounding the valley, we investigated those nests separately. For non-riparian nests, the mean canopy cover at nest sites was 67% (SD = 9.8, range = 45-81). Mean distance from the nest to meadow was 218 m (SD = 133, range 77-600 m). While sample size was limited ($n = 3$), nests within the Snake River bottom had a mean canopy cover of 40% (SD = 18, range = 24-61) and a mean distance to meadow of 75 m (SD = 66, range = 0-121). Forests nests had significantly more canopy cover ($t = 3.96$, $p < 0.001$) and were further from the forest edge ($t = 1.80$, $p = 0.043$) than riparian nests. The mean elevation for nests was 2,052 m (range = 1,850-2,404) and mean slope was 8.2% (range = 0.2-27.5). We found that the majority of nests were situated on north aspects (50%), followed by east (33%), south (12.5%), and west (0.5%).

Using the remote sensing data, we only investigated habitat variable influence on nesting success for 2015 because most nesting data existed for that year. Nests in snags had lower success compared with stick nests and mistletoe ($F = 4.49$, $p = 0.025$). We found no difference between successful and failed nests for canopy cover or distance-to-edge. We did find that nest site elevation was positively correlated with fledge date in 2015 ($P = 0.031$). Likewise, fledge date was also correlated to latitude ($p = 0.028$) because of a strong correlation between latitude and elevation ($p = 0.003$). However, these results were strongly influenced by 1 high altitude nest (2,404 m) in the northern portion of the study area (Rosie's Ridge). After removing this outlier, fledge dates were correlated to latitude ($p = 0.007$) but not elevation ($P = 0.085$).

Nesting Density

We identified territories when multiple detections of males and/or a female detection were recorded within a 500-m radius. In known, active territories, Great Gray Owls were rarely detected at the nest. More typically, detections occurred within a 500-m radius of the nest and most often near the territorial boundary. Retrospectively investigating call detections and known, active territories, we found 5 nest sites at which night call detections did not identify a territory (i.e., no calling or fewer than 3 male detections). Combining all known territories and estimated territories from detections, we found a total of 40 occupied Great Gray Owl territories within the areas we surveyed and searched.

We surveyed a total of 114.2 km^2 of forested habitat among years for calling owls using the nighttime callback technique. Using the known and estimated territories, we found a territory density for Great Gray Owls of 1 occupied territory per 3.57 km^2. We effectively searched 54.0 km^2 of forested habitat for nests within the southern portion of our study area. Within that area, we located 20 known, active nest sites, giving a nesting density of one nest per 2.7 km^2. We found an average nearest neighbor distance of 914 m. We tested for a clumped distribution of active territories using Ripley's K-function in ArcMap (Fisher et al. 2007) with 99 permutations for a confidence interval and found no evidence of clustering within our study area.

Using our breeding season habitat models, we calculated the percentage of cells ≥ the top 10% surrounding each cell; that is, ≥ the top 10% predicted area within a 500-m radius surrounding that cell (see below). So, we effectively reduced our model to only include cells that had at least 50% of the surrounding cells within 500 m that were also in the top predicted habitat to define areas that are available for breeding. This measure took into account that some cells of predicted habitat did not have much habitat surrounding them and, therefore, were not likely available to owls for breeding. Using this measure, we estimated a total are of 279.43 km^2 within and directly surrounding the Jackson Hole Valley (excluding the east side of the Tetons and south of the Snake and Hoback Rivers) as potentially available for Great Gray nesting.

Nesting Platforms

We set up 24 nesting platforms during fall 2013 and an additional 18 in 2014. We found that Duracell UltraLithium batteries generally lasted up to 1 year. By the winter of 2014-2015, 3 nesting platforms erected in 2013 had been discovered by Great Gray Owls. One of these nesting platforms was used by a Great Gray Owl pair in the 2015 breeding season. That pair successfully fledged 3 chicks. We found no other species nesting in platforms, but did detect red squirrels, pine martins, and a variety of songbirds at platforms throughout the years.

Tagging and Tracking

Between 2013 and July of 2015, we captured a total of 71 individual Great Gray Owls, all of which we banded. We outfitted 33 Great Gray Owls with transmitters, deploying 19 VHF transmitters on juvenile, sub-adult, and adult owls, and 13 GPS transmitters on adult owls (Table 1). We used blue color bands on owls captured as sub-adults or adults, yellow on 2014 fledglings, and orange on 2015 fledglings. Of the 33 transmitters we put out on Great Gray Owls, 14 are still transmitting. Eight of the units stopped transmitting (battery died), 2 of the transmitters fell off the birds, and we removed 3 of the GPS transmitters by recapturing the owls. We deployed 4 store-on-board GPS units in 2013, but we were unable re-locate 3 of these owls to recover their units. Subsequently, we deployed only remote-download GPS so we would not have to recapture individuals. However, the expected lifespan of the transmitters was greater than the observed lifespan, so we had to recapture several owls in 2015 to recover the final data from the units. We were unable to recapture 1 owl with a dead transmitter, and could not relocate another. Two owls with VHF transmitters are missing, but it is assumed their transmitters are still functioning. During the course of our study, we gathered a total of 702 relocations from VHF marked birds, and an additional 1731 relocations from GPS marked owls.

Table 1. Transmitter deployment records for Great Gray Owls (*Strix nebulosa*) in Jackson Hole, Wyoming from 2013-2015.

Year	Fledgling			Sub-Adult			Adult			Total
	Band	VHF	GPS	Band	VHF	GPS	Band	VHF	GPS	
2013				1	2	2		3	2	10
2014		7			2			4	8*	21
2015	39							1	1	41
Total	39	7	0	1	4	2	0	8	11	72*

* includes one recapture and deployment on previously marked owl

We estimated breeding season home ranges for all sub-adult and adult owls for which we had sufficient data. We restricted the breeding season to 1 May – 31 August, and separated owls by breeding status. For owls with multiples years of data, we combined movement data if the breeding status was the same among years, and separated years if the breeding status changed. We found that the average MCP estimate for breeding owls (n = 7 females, 3 males) was 1.53 km^2 (range = 0.18-4.47, SD = 1.39) and non-breeding owls (n = 7) was 14.41 km^2 (range = 2.78-76.69, SD = 27.60). However, 1 non-breeding adult female exhibited a very atypical home range, inflating the average. Her MCP was 76.69 km^2, while the next largest MCP was 8.4 km^2. Excluding her MCP, the average was 4.03 km^2 (SD = 2.48 km^2). We found (both with and without the atypical female), that MCPs for non-breeding owls was larger than breeders (p = 0.0084, W = 88.0). However, we found no difference in MCP size between breeding males (n = 3) and breeding females (n = 7; p = 0.58).

We also estimated KDEs for the owls during the breeding season. We used 50, 75, and 95% KDEs. Visual inspection of the data, confirmed by our field observations, nighttime callback locations and re-locations, suggested that 75% KDEs (0.83 km^2, range = 0.18-1.96, SD = 0.59) are the most appropriate for estimating home range of owls in our study area. Based on a circular home range surrounding the nest, the average 75% KDE for breeding owls equals a 514-m radius around the nest, which corresponds to the typical call distance of territorial owls encountered during nighttime surveys, corroborating that using a 75% KDE is appropriate for this population. We found that the 75% KDEs for non-breeding owls (mean = 6.60 km^2, range = 2.43-60.87, SD = 20.78) was larger than breeding owls ($p = 0.002$, $W = 93.0$). Excluding the atypical non-breeding owl did not affect the difference. Using a 50% KDE to estimate core area for breeding owls, we found a mean 50% KDE of 0.35 km^2 (range = 0.05-0.87, SD = 0.26). This equates to a core area within a 334-m circular area centered on the nest site.

Because we restricted the dates for wintering areas to the core winter times (15 December – 31 January), we had limited samples sizes of relocations, and we could not create KDEs for individuals with VHF transmitters. Therefore, we created a population level KDE of critical winter range using VHF marked owls in addition to individual KDEs for GPS marked owls. We found that the entire winter range (75% KDE) for Great Gray Owls within our study area was 111.3 km^2 (95% KDE = 148.2 km^2). The individual 75% KDE estimates for the 3 wintering GPS marked owls was 0.89, 2.0, and 5.7 km^2.

We measured the distance from the center of winter and summer ranges for all owls for which we had multiple season data ($n = 15$). The total mean distance for all owls moved between ranges was 12.2 km (range = 0.00-52.50). The mean distance moved for juvenile owls ($n = 7$) was 9.21 km, while adults ($n = 8$) moved an average of 14.8 km between winter and summer ranges. All but 1 owl had discrete winter and summer ranges, with winter ranges typically within the Snake River corridor. We found no differences in mean movements between adults and juveniles ($p = 0.39$). We did not re-locate 2 owls (a mated male and female) from the southern extent of our study area during the winter months. GPS relocations from the female in the fall suggest that they may have wintered further south (closer to Alpine, Wyoming) than other owls in this study. We also marked several individuals during the winter months that could not be relocated in the summer, suggesting some owls are dispersing more widely.

Habitat Use

We measured habitat use of breeding owls and wintering owls by extracting habitat remote covariate data from within each owl's home range. We used the 75% KDE because we were not interested in assessing habitat use at the fringe (or infrequently used portions) of the territories. We used our reclassified 2011 NLCD layer to estimate percentages of habitat type with the home ranges (Tables 2-5). We found the highest percentage of habitat used within the breeding season was conifer forest, followed by meadow (Table 2). In the winter, owls used a much greater proportion of riparian forest and meadows. We did find that the average habitat percentages were different when comparing the population level winter KDE to individuals. However, the individual level is likely more representative of how owls are using the habitat on a fine scale.

Table 1. Percentage of land cover classes within the 75% KDE for Great Gray Owls (*Strix nebulosa*) during the breeding season in western Wyoming.

Land Cover	A3	A5	A7	A8	C3	C5	E4	E6	E7	Mean
water/Ice/Rock	0.0	0.0	0.0	0.0	0.0	11.4	0.0	0.0	0.0	1.3
Developed	0.0	0.0	0.0	0.0	3.2	1.5	0.0	0.0	0.0	0.5
Deciduous (Aspen) Forest	16.3	6.4	0.4	6.0	0.1	0.0	0.6	5.2	0.0	3.9
Conifer Forest	74.0	76.6	90.7	89.8	72.0	53.7	63.0	93.5	82.2	77.3
Mixed (Riparian) Forest	3.5	0.6	0.0	0.3	3.1	8.4	0.0	0.0	3.5	2.1
Meadow	6.2	16.4	9.0	4.0	21.6	25.1	36.4	1.3	14.3	14.9
Pasture/Crops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. Percentage of land cover classes within the 75% KDE for Great Gray Owls (*Strix nebulosa*) during the winter in western Wyoming.

				Mean	Mean
Land Cover	E3	E4	E7	GPS	VHF
water/Ice/Rock	0.0	0.0	5.0	1.7	3.4
Developed	0.0	1.2	1.5	0.9	2.5
Deciduous (Aspen) Forest	0.0	0.0	0.1	0.0	2.5
Conifer Forest	0.0	1.4	9.8	3.7	34.6
Mixed (Riparian) Forest	50.9	68.2	27.9	49.0	18.7
Meadow	49.1	29.2	33.5	37.3	37.6
Pasture/Crops	0.0	0.0	22.1	7.4	0.8

Table 3. Top nine breeding habitat models and selection criteria.

Intercept	Aspect	Distance to Road	Elevation	Vegetation Height	Distance to Meadow	% Canopy Cover	Slope	df	logLik	AICc	delta	weight
-3.254			-0.814	0.203		0.524	-0.906	6	-1938.13	3888.3	0	0.322
-3.252	0.033		-0.813	0.202		0.526	-0.906	7	-1937.80	3889.6	1.33	0.165
-3.259			-0.819	0.190	-0.034	0.545	-0.907	7	-1937.91	3889.8	1.55	0.148
-3.256		-0.013	-0.810	0.202		0.523	-0.903	7	-1938.10	3890.2	1.95	0.122
-3.257	0.032		-0.818	0.190	-0.033	0.546	-0.908	8	-1937.59	3891.2	2.93	0.075
-3.254	0.033	-0.012	-0.810	0.201		0.525	-0.903	8	-1937.77	3891.6	3.29	0.062
-3.261		-0.012	-0.815	0.190	-0.034	0.544	-0.905	8	-1937.88	3891.8	3.51	0.056
-3.259	0.032	-0.011	-0.814	0.189	-0.032	0.545	-0.905	9	-1937.57	3893.2	4.89	0.028
-3.315			-0.819		-0.078	0.586	-0.902	6	-1942.06	3896.1	7.86	0.006

Table 4. Top breeding season model coefficient estimates.

	Estimate	Std. Error	z value	Pr(>|z|)	Significance Level α
Intercept	-3.25376	0.11889	-27.367	< 2e-16	0.001
Forest	1.63329	0.14667	11.136	< 2e-16	0.001
Elevation	-0.81355	0.05704	-14.262	< 2e-16	0.001
Veg Height	0.20263	0.06915	2.93	0.00339	0.01
% Canopy Cover	0.52354	0.05751	9.103	< 2e-16	0.001
Slope	-0.90548	0.06065	-14.93	< 2e-16	0.001

Habitat Modeling

We found that reducing the categories within the land cover dataset to forest/non-forest significantly improved model fit of the breeding season models compared to the more inclusive land cover raster. Using forest/non-forest as our land cover covariate, the top model showed selection for treed habitat with greater height and canopy cover that was further from roads and had lower slope and elevation (Tables 2-5, Figures 5-8).

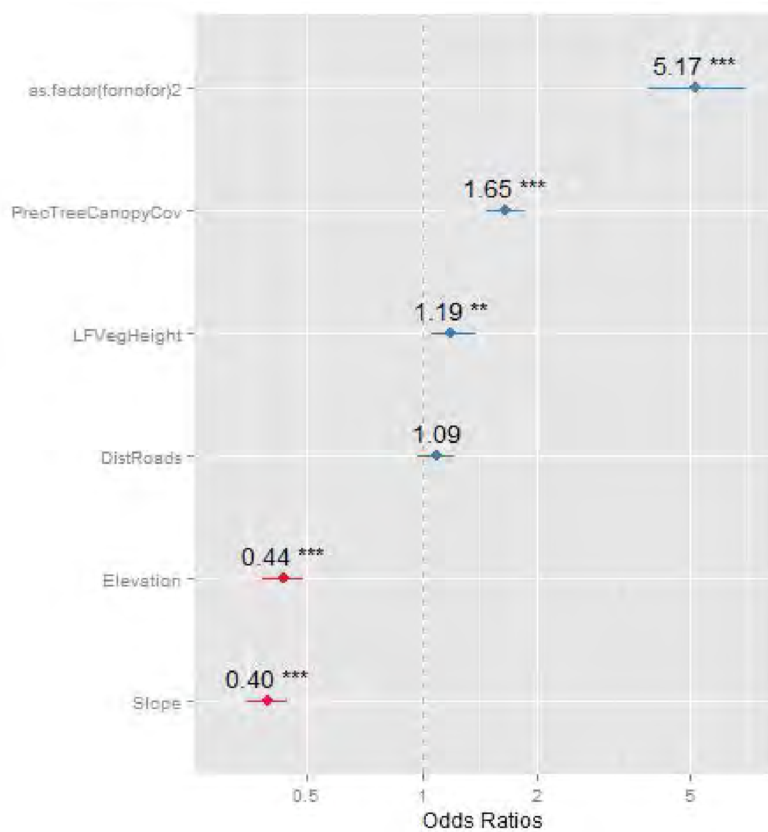

Figure 5. Breeding season model coefficient selection ratios.

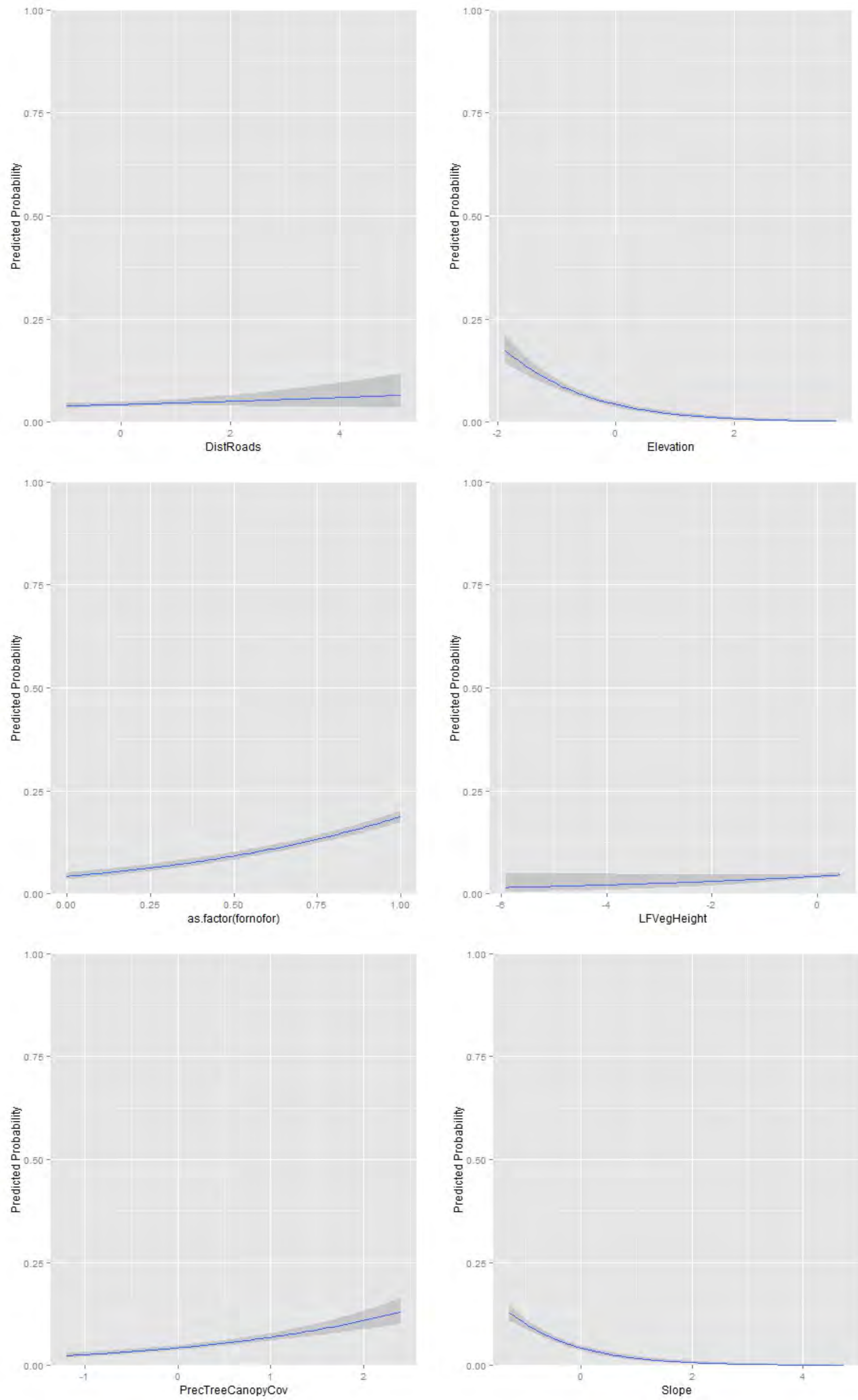

Figure 6. Breeding season model coefficient predicted probabilities.

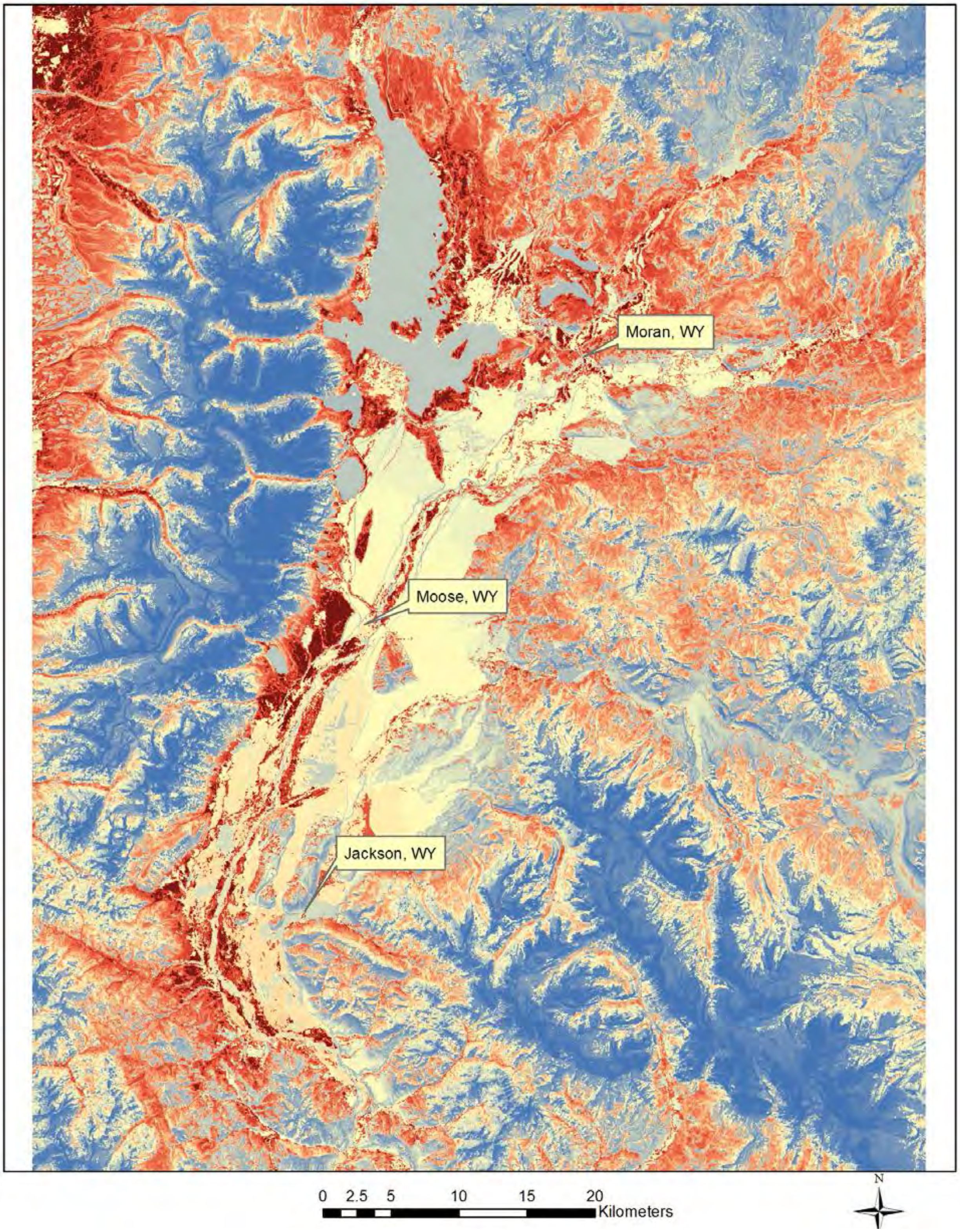

Figure 7. Great Gray Owl (*Strix nebulosa*) breeding resource selection model. Blue indicates areas with low probability of use and red indicates high probability of use. Darkest red corresponds to the top 5% of the model.

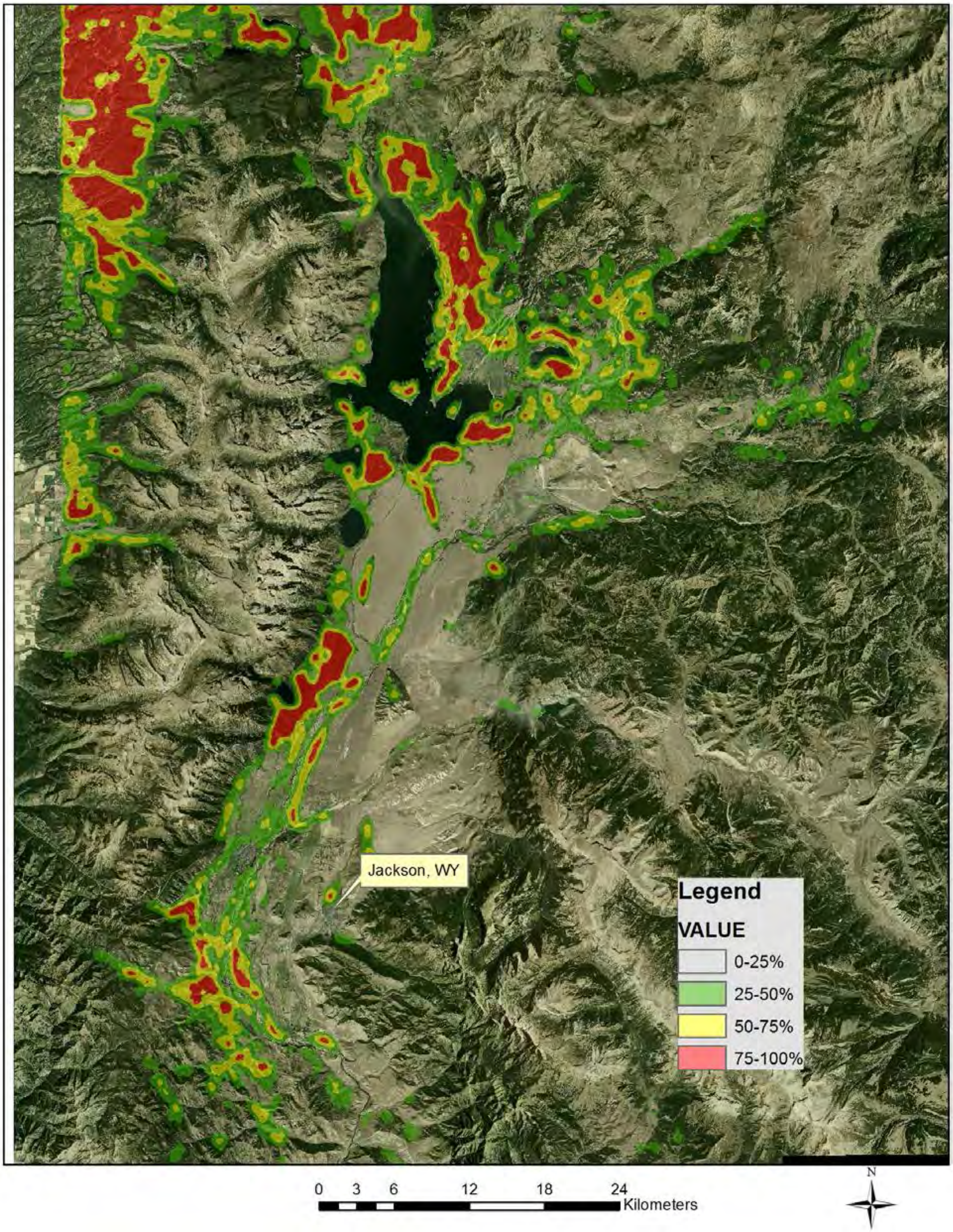

Figure 8. Areas within the top 10% of the breeding season RSF models with the percentage of neighboring cells within 500 m that also are within the top 10% of predicted habitat.

We also created a model of critical winter habitat for Great Gray Owls within Jackson Hole. For this model, we used our second-order level land cover ranking, which separated different forest types and meadows. We chose this level because our field observations of winter movements suggested a differentiation between conifer and riparian forests may be an important factor for winter range. Contrary to the breeding habitat models, the critical winter resource selection model predicted that owls had an affinity for nearer proximity to roads, lower elevation, and areas closer to meadows (Tables 6 and 7, Figures 9 and 10). There was essentially no critical winter habitat predicted in Jackson Hole north of the map extent in Figure 9.

Table 5. Top nine critical winter habitat models and selection criteria for Great Gray Owls (*Strix nebulosa*) in western Wyoming.

Intercept	Aspect	Distance to Road	Elevation	Veg Height	Distance to Meadow	% Canopy Cover	Slope	df	logLik	AICc	delta	weight
-1.833		-1.208	-2.64		0.140		-0.180	9	-775.267	1568.6	0	0.152
-1.641		-1.194	-2.64	0.093	0.162		-0.185	10	-774.74	1569.6	0.97	0.094
-1.785		-1.216	-2.782		0.148			8	-777.036	1570.1	1.52	0.071
-1.785		-1.205	-2.643		0.129	0.064	-0.192	10	-775.136	1570.4	1.76	0.063
-1.832	0.0060	-1.207	-2.64		0.140		-0.180	10	-775.263	1570.6	2.01	0.056
-1.731		-1.137	-2.611				-0.189	8	-777.377	1570.8	2.2	0.05
-1.874		-1.188	-2.656		0.171	0.239	-0.221	6	-779.625	1571.3	2.67	0.04
-1.614		-1.205	-2.786	0.083	0.168			9	-776.617	1571.3	2.7	0.039
-1.619		-1.193	-2.642	0.088	0.153	0.045	-0.194	11	-774.679	1571.5	2.86	0.036
-1.65		-1.146	-2.621			0.135	-0.214	9	-776.727	1571.5	2.92	0.035
-1.64	0.0059	-1.194	-2.64	0.093	0.162		-0.185	11	-774.736	1571.6	2.98	0.034

Table 6. Winter model coefficient estimates.

	Estimate	Standard Error	z value	Pr(>|z|)	α level
(Intercept)	-1.833	0.238	-7.690	1.47E-14	0.001
Conifer Forest	0.330	0.236	1.395	0.163	
Deciduous Forest	0.198	0.296	0.669	0.5038	
Riparian Forest	1.848	2.071	0.892	0.3722	
Meadow	-0.353	0.211	-1.674	0.0941	0.1
DistRoads	-1.208	0.188	-6.432	1.26E-10	0.001
Elevation	-2.640	0.209	-12.611	< 2e-16	0.001
MeadDis	0.140	0.068	2.055	0.0399	0.05
Slope	-0.180	0.095	-1.884	0.0595	0.1

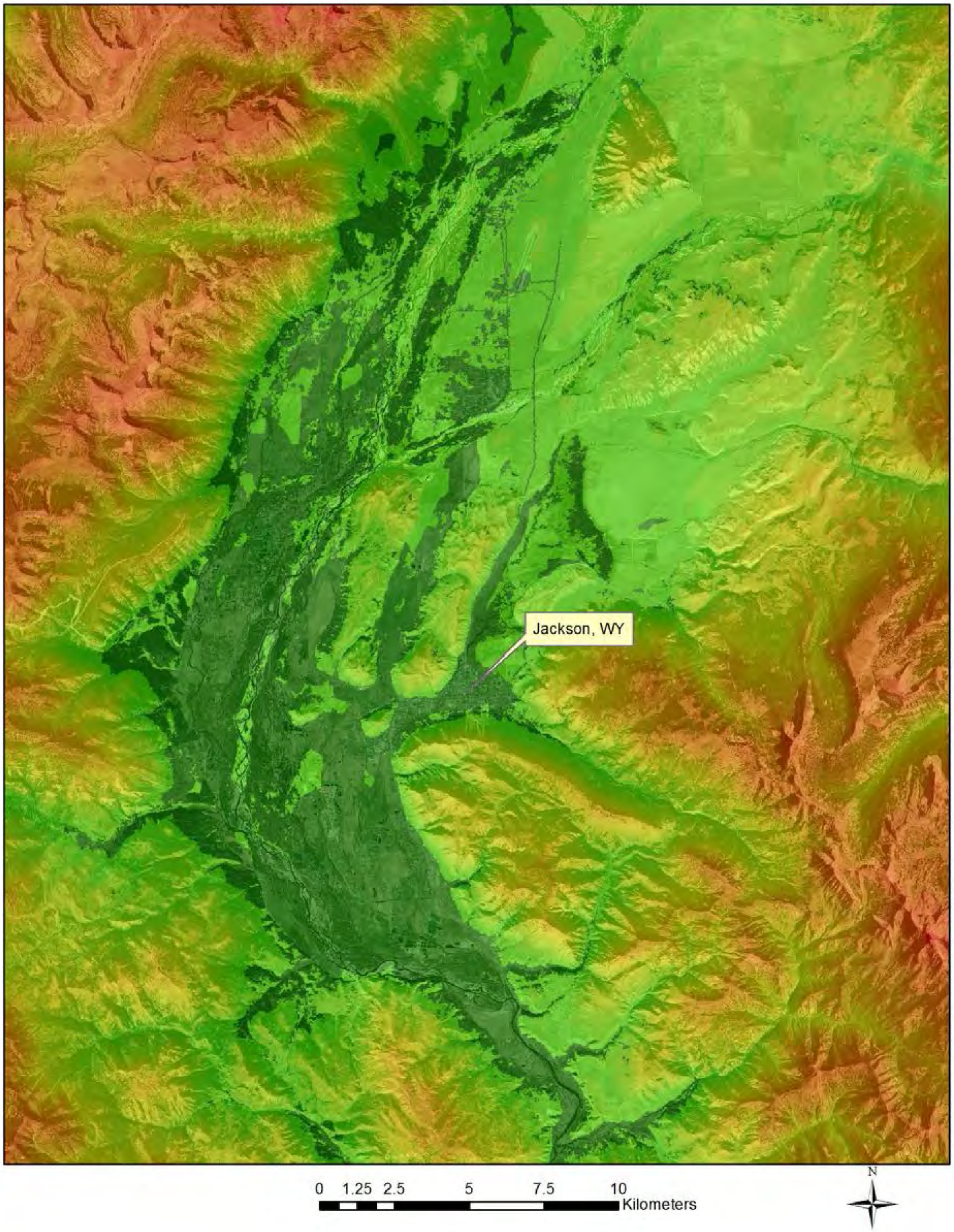

Figure 9. Great Gray Owl (*Strix nebulosa*) critical winter resource selection model. Red indicates areas with low probability of use and green indicates high probability of use. Darkest green corresponds to the top 7.5% of the model.

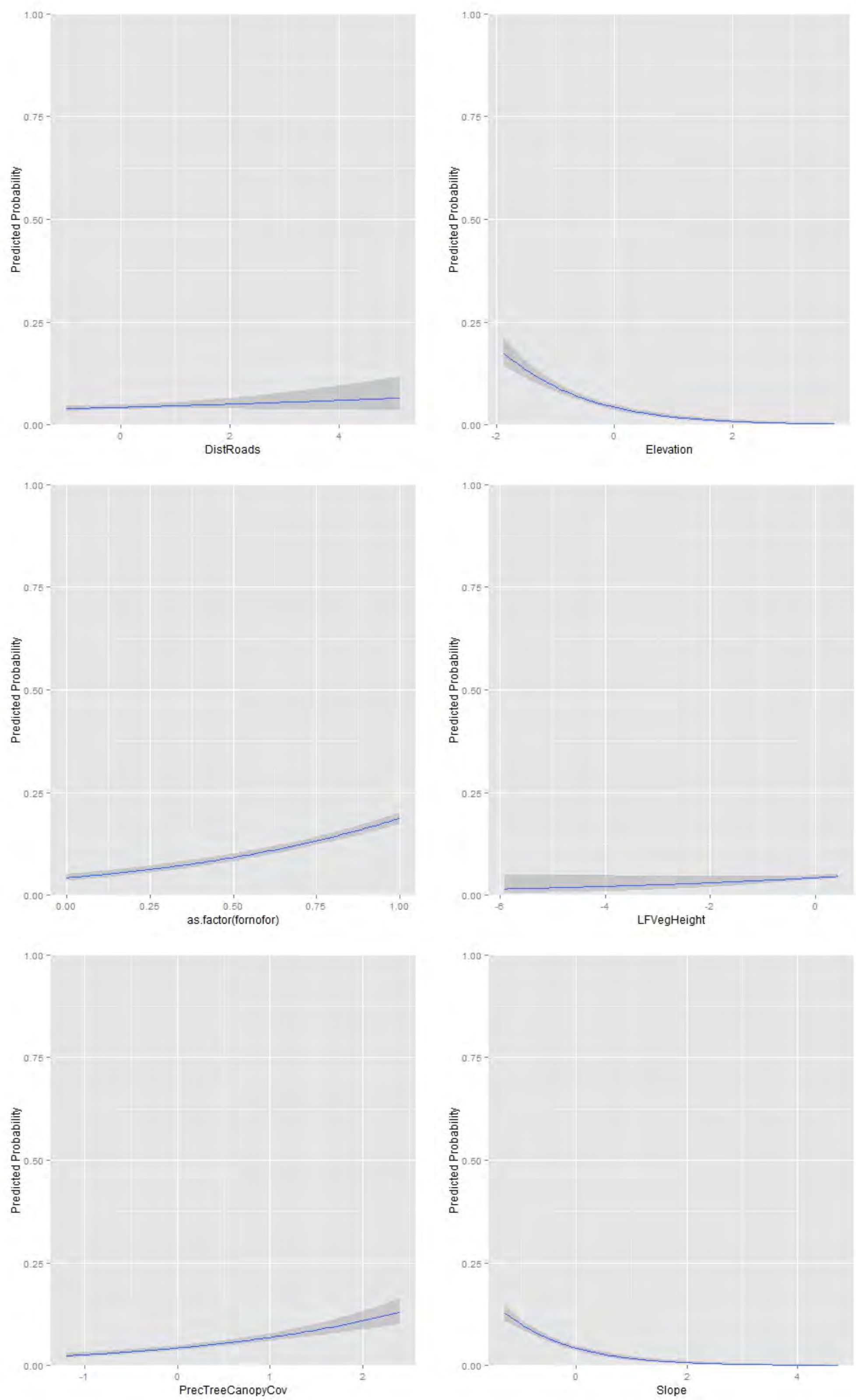

Figure 10. Winter model coefficient selection ratios and predicted probabilities.

Prey Sampling

Pocket Gopher Surveys

We completed pocket gopher surveys in 2014 and 2015 at all known nesting territories. We estimated gopher abundance in 10 territories in 2014 and 21 territories in 2015. We surveyed an average of 4,974 m^2 per territory (249-m survey length) in 2014 and 3,548 m^2 per territory (177-m length) in 2015. Using only fresh mounds to estimate abundance, we found significantly fewer gophers (mean = 0.00000230 mounds per m^2) in 2014 than 2015 (mean = 0.00000442 mounds per m^2, $t = 1.76$, $p = 0.044$). Based on linear transect distance and not area (see van Ripper et al. 2013), we found 0.013 and 0.028 mounds per m in 2014 and 2015, respectively. Failed territories had fewer pocket gophers than successful territories ($t = -3.02$, $p = 0.003$), but we did not detect a relationship between gopher abundance and number of fledglings at successful nests ($F = 1.03$, $p = 0.400$).

Small Mammal Trapping

We conducted small mammal trapping at 14 different territories and suspected territories from 2013-2015. We trapped at 9 territories for at least 2 years and 5 of those all 3 years. We encountered several instances in which suspected territories were not confirmed or the territory was first located in 2015. Each site was sampled at both a forest and meadow location for 3 consecutive morning and evening sessions.

The most abundant species encountered were chipmunks (*Neotamias* spp.), followed by deermice (*Peromyscus maniculatus*), southern red-backed vole (*Clethrionomys gapperi*), dwarf shrew (*Sorex nanus*), long-tailed vole (*Microtus longicaudus*), western jumping mouse (*Zapus princeps*), northern flying squirrel (*Glaucomys sabrinus*), and pocket gopher (*Geomys bursarius)*. We used the data from all territories sampled with multiple years for to investigate annual differences in abundance of each group by forest or meadow site. We combined small mammals into a vole, chipmunk, and mice categories and excluded other species encountered due to low sample sizes.

We found no significant differences among years for any small mammal group in either forest or meadow sites (all $p > 0.05$). There is some evidence to suggest there were more chipmunks in meadows during 2015 than the previous years ($p = 0.096$). We also investigated the total territorial small mammal abundance with productivity by combining all small mammal estimates for a given territory testing for influence on productivity for that year using an ANOVA test and found that total small mammal abundance did not differ by the number of fledglings produced ($p = 0.324$). Nor could successful or failed nests be predicted by the total small mammal abundance using a binary logistic regression ($p = 0.277$).

Pellets

We collected 86 Great Gray Owl pellets in 20 territories throughout the study area from May 2013 to July 2015. Those pellets contained 157 prey items with a mean of 1.8 prey items (defined by at least one skull or mandible) per pellet. The number of skulls/mandibles that indicated a separate individual ranged from 0 to 5 per pellet. Since skull or lower jaw bones had to be present for identification, decapitated prey items were not accounted for.

We found that Great Gray Owl diet consisted entirely of rodents except for 2 shrews and 1 mustelid. The species identified were *Thomomys talpoides* (northern pocket gopher), *Myodes gapperi* (southern red-backed vole), voles of the genera *Microtus* and *Phenacomys* (montane vole, meadow vole, long-tailed vole, and western heather vole), *Peromyscus maniculatus* (deermouse), *Zapus princeps* (western jumping mouse), *Tamiasciurus hudsonicus* (red squirrel), *Tamius amoenus* (yellow-pine chipmunk), *Glaucomys sabrinus* (northern flying squirrel), shrews in the genus *Sorex* (masked shrew and vagrant shrew), and *Mustela frenata* (long-tailed weasel). Two unknown mandibles with teeth missing appeared to be mice or chipmunks. Great Gray Owls primarily fed on pocket gophers (both by frequency and biomass) and voles (Table 8).

Table 7. Species, frequency, and biomass estimates of small mammal biomass found in Great Gray Owl (*Strix nebulosa*) pellets in Jackson Hole, Wyoming, 2013-2015.

Prey	*N*	Frequency (%)	Biomass (g)	Biomass (%)
Pocket Gophers	82	53	5,666	64
Voles	58	37	2320	26
Mice	7	5	154	2
Chipmunks	1	1	200	2
Red Squirrels	1	1	213	2
Flying Squirrels	3	2	110	1
Shrews	2	1	20	0
Weasels	1	1	150	2

Nest Cameras

In the fall of 2013, we placed 3 cameras at nest sites that were identified previously that year to monitor nests in 2014. Two cameras were situation laterally from the nest in an adjacent tree and 1 was situated in the nest tree directly above the nest. We also had an additional camera on an active platform in 2015, in addition to the cameras already at nests. After reviewing the still images captured, we could not accurately assess prey items, prey delivery rates, or breeding behaviors of the females. The cameras did not regularly capture images, probably a result of distance from the nest or low sensitivity settings on the motion trigger. Often, prey exchanges would take place outside the view of the camera and/or the adult would be blocking the view of the prey item. Future camera placements should be closer to the nest and multiple cameras from different angles may help refine this technique.

Survivorship

Over the course of our study, 4 of our tagged owls died. One sub-adult owl and 1 juvenile owl died of injuries caused by vehicle collisions, 1 sub-adult mortality was due to a suspected predation, and 1 breeding adult owl died of Trichomoniasis. Trichomoniasis (*Trichomonas gallinae)* is a protozoan parasitic infection that causes lesions in a bird's throat, restricting its ability to swallow and has been documented in 2 Great Gray Owls in California (Rogers 2014). The disease is primarily carried by Rock Pigeons (*Columbia livia*) and doves. Pigeons are very rare within Jackson Hole, but there is a relatively small population of Mourning Doves (*Streptopelia decipiens*) and an increasing population of Eurasian Collared-Doves (*Streptopelia decaocto*). The owl that succumbed to Trichomoniasis was a breeding female with fledglings that was nesting in the Snake River bottom among low-density housing. It is likely that this Great Gray Owl preyed upon doves to contract Trichomoniasis. We searched for the fledglings following the mortality of the female but were unable to locate them, suggesting they may have also succumbed to Trichomoniasis.

Tail Molt

We studied the molt patterns of sub-adult and adult Great Gray Owls throughout the study. Replacement of rectrices occurred in what is known as a "simultaneous" or rapid, complete molt over the course of several days, rendering the owls temporarily "tail-less". Rectrices were lost either in unison or centrifugally (from the innermost to outermost), but molt always occurred rapidly, usually within a couple of days and at the most within 2 weeks. No disjunct, or gradual, tail molt was observed, whereas the simultaneous molt pattern was seen in adult breeding, adult non-breeding, and sub-adult owls. In all, we observed 18 occurrences from 16 individual Great Gray Owls undergoing rapid, complete tail molt. We did not observe any owls that did not exhibit this type of simultaneous tail molt.

We only observed one sub-adult in 2013 that we know exhibited simultaneous tail molt, and we increased observation efforts in 2014 and 2015 to determine average dates of tail molt and if this was a universal phenomenon in Great Gray Owls. In 2014, we observed 8 breeding owls, 1 non-breeder, and 1 owl with unknown breeding status that molted their tails simultaneously. The average molt date was 17 July 2014 (range = 24 June – 14 August). In 2015, we compiled simultaneous molt observations from 5 breeding adults and 2 sub-adults, with an average molt date of 4 July 2015 (range = 10 June – 25 July).

Little documentation exists regarding the molt patterns of Great Gray Owls and information surrounding the tail molt sequence in particular is limited. We observed 17 sub-adult and adult Great Gray Owls molting their tails completely and rapidly. Mayr and Mayr (1954) believed tail molt was gradual in large owl species but simultaneous in small owls. However, rapid, complete tail molt has since been documented in both Spotted Owls (*Strix occidentalis*) and Barred Owls (*Strix varia*; Forsman 1981). We found no record of simultaneous tail molt in Great Gray Owls previous to our study. The advantages and implications of this molt pattern are not well understood. We observed no flight impairment due to tail loss and no connection between simultaneous tail molt and survivorship or nest success was apparent. More research investigating the benefits and impacts of owls undergoing a rapid, complete tail molt is warranted.

DISCUSSION

Most studies of forest owl abundance and distribution rely on nighttime surveys. Nighttime playbacks proved to be an effective, but labor-intensive, method for surveying boreal forest owls, particularly Great Gray Owls. However, several key ecological and behavioral factors play important roles on how detectability rates and how detections can be interpreted. Duncan (1987) and Bull and Henjum (1990) suggested that Great Gray Owls defend the nest itself and not the territory. Contrary to these studies, we generally documented Great Gray Owls calling closer to the perimeter of the territory, which suggests that Great Gray Owls in Wyoming are defending the territory boundary, which has been also been suggested for California populations (Reid 1989).

Seasonal and annual fluctuations in the number and timing of boreal forest owl species responding to playback recordings indicate that there are limitations to callback surveys and interpretation of the survey results. Callback detections and timing of forest owls can vary widely (Francis and Bradstreet 1997) depending on factors such as moon phase (Ibarra et al. 2014) and weather (Wintle et al. 2005). Winter (1986) found that Great Gray Owl call response in California peaked at 2200 and 0100 hours, but we found relatively consistent detections for Great Gray Owls throughout our survey periods. However, we rarely continued surveys after 0130 hour, so detectability in the early-morning hours still remains unknown in this region. Furthermore, estimated owl population abundance is likely influenced by other factors such as prey availability and snowpack (Francis and Bradstreet 1997, Palmer 1987, Duncan and Duncan 1997). High prey availability can possibly lead to inflated population estimates due to sub-adults or floaters trying to establish territories. Conversely, in years of low prey abundance, estimates may be deflated because breeders may temporarily migrate or be occupying territories but choose not to breed and, therefore, reduce territorial calling (Lane et al. 1997).

We estimated our night survey detectability based on how often we heard Great Gray Owls within known territories. We found that detectability always increased in territories that were resurveyed, and multiple surveys (>2) are likely needed to accurately assess occupancy. Further, seasonal timing of Great Gray Owl response can fluctuate from year to year. Our low detection rates during a year of high snowpack suggest more studies are needed to understand detectability of Great Gray Owls and influences to detectability. In years with increased snowpack, we suggest lengthening callback periods to account for delayed nesting. Future studies using automated recorders are planned to better assess calling detectability.

Factors such as snowpack not only affect Great Gray Owl detectability, but also nesting demographics. We detected fewer Great Gray Owls in 2014 and fewer nesting attempts, likely resulting from increased snowpack that year. High snow loads with hard crust layers may preclude owls from successfully hunting within higher-elevation territories. Mean annual fledge dates were later in 2014, suggesting that the owls delayed reproduction in 2014 until snowpack decreased. We also found that later nest initiation dates were also correlated to latitude within the study area, which is consistent with higher spring snowpack at these more northern sites. This corroborates previous studies where Great Gray Owls initiated incubation later in years of higher snowpack (Franklin 1988, Bull et al. 1989).

Great Gray Owls rely on small mammals for prey, feeding primarily on northern pocket gophers and/or voles in Idaho and Wyoming, northeast Oregon, and Yosemite National Park (Franklin 1988, Bull and Henjum 1990, Winter 1986, Whitfield and Gaffney 1997, Fetz et al. 2003). Our data are consistent with previous studies in this region, indicating that Great Gray Owls are primarily relying on pocket gophers as prey (see Table 8; Franklin 1988). Gophers typically do not exhibit large population fluctuations like vole species and can offer a more consistent prey base, though small changes in gopher population densities do occur. Changes in primary prey populations dictate owl dispersal, survivorship, and breeding (Duncan 1987, Hilden and Helo 1981, Nero 1980, Pulliainen and Loisa 1977, Bull and Henjum 1990). Bull and Henjum (1990) noted that most Great Gray Owls nested every year between 1982 and 1988 except 1987, which corresponded with a crash in prey populations.

We noted fewer northern pocket gophers in 2014 than 2015, suggesting that a decline in prey populations, combined with a harsher winter, may have limited Great Gray Owl detectability and nesting attempts in 2014. We not only detected fewer Great Gray Owls during callback surveys, but we also observed fewer nest attempts that year. We documented several occupied territories in 2014 but did not find active nests sites at locations we subsequently did in 2015, suggesting that a decline in prey availability restricted owl breeding that year. Furthermore, failed nest sites had fewer pocket gophers than successful territories, suggesting that prey populations also likely impacts nesting success.

Over the course of the study, we documented 36 Great Gray Owl nest attempts, and our observed high overall nest success was comparable to that found in other studies (Bull et al. 1989, Franklin 1988, Whitfield and Gaffney 1997). However, while nest success was high, we found that productivity has been steadily decreasing in western Wyoming over the past 30 years. In previous studies adjacent to and overlapping our study area, mean productivity was 3.0 fledglings per nest in 1980-1984 (Franklin 1988), 2.3 fledglings per nest in the mid-1990s (Whitfield and Gaffery 1997), while we found an average of 1.7 fledglings per nest during this study. While territories with fewer pocket gophers had lower nest success, gopher counts did not appear to impact the number of young fledged, although this may be a product of low sample size and few years sampled. Franklin (1988) found that fledgling success was higher at nests where pocket gophers comprised a higher percentage of the owls' diet. More extensive, long-term analysis of prey abundance, diet, and productivity is warranted to better understand why Great Gray Owl productivity has apparently decreased in productivity over the past 30 years.

We observed Great Gray Owls nesting in relatively close proximity (less than 500 m) to one another, but our estimate of density (1 pair per 3.6 km^2) is lower than other reported densities for this species. Bull and Henjum (1990) recorded 1 pair per 1.34 km^2 and 1 pair per 0.58 km^2 in 2 different study areas in Oregon, Duncan (1987) observed 1 pair per 0.53 km^2 in Manitoba, Winter (1986) found one pair per 1.51 km^2 in California, and Spreyer (1987) found one pair per 6.66 km^2 in Minnesota. Duncan (1997) suggested that Great Gray Owls may be "loose colonial nesters". However, we found that Great Gray Owls do not exhibit a clustered nesting distribution within our study area. Fisher et al. (2007) found that definition of study areas as they relate to the spatial distribution of nests can greatly influence estimates of nesting density. Differences in study area calculations based on how areas searched are defined may account for variability in observed densities.

Regular spacing coupled with our observations of calling locations suggests that owls are defending territories. Defense of territories instead of just the nest further suggests that the resources (i.e., prey) within the territory are limited. Limited prey resources may also explain lower densities and decreases in productivity over time. Further work should explore nest spacing in Great Gray Owls and how/if nest density and spacing relates to prey densities, productivity, and nest defense.

The reasons nesting density is relatively low and productivity has decreased across time are not completely clear. It is likely that studies areas for Great Gray Owls are chosen based on a perceived high density of owls (Duncan 1997), and lower density areas may not be surveyed often. If this is the case, then comparing densities across studies may not be that informative. Rather, long-term monitoring to document changes in density would better inform managers about population health.

In addition to weather and prey influences on nesting demographics, habitat quality and availability within the territory, and foraging areas is a clear factor in nesting demographics and also influences prey populations (Duncan 1997). Several studies have quantified habitat use across the species' range, including Whitfield and Gaffney (1997) who quantified habitat use within the Greater Yellowstone Ecosystem. Previous studies have found that Great Gray Owls prefer to nest in larger patches of mature forest stands with high canopy cover (e.g., Bull and Henjum 1988, Stepnisky 1997, Fetz et al. 2003). No other study has quantified habitat use of Great Gray Owls utilizing radio telemetry.

According to Duncan (1997), nest site availability may limit Great Gray Owl nesting abundance in some areas. We tested this hypothesis in western Wyoming through use of nesting platforms. Great Gray Owls have readily nested on man-made platforms in timber-harvest areas (Bohm 1985, Bull et al. 1987, Nero 1982), and platforms have been used to indicate if there is a shortage of adequate natural nesting sites (Sulkava and Huhtala 1997). Beginning in 2013, we installed nesting platforms in a portion of the study area to investigate if increasing nest sites would increase nesting density compared to our control area. By the end of 2014, 3 of 42 platforms had been visited by Great Gray Owls, although 1 of these encounters was only by fledgling owls. Only 1 of these platforms was used for nesting, and that pair successfully fledged 3 chicks. It took 2 years for these 3 platforms to be discovered, so it may be too early to determine whether the number of nesting Great Gray Owls are limited by nest availability since some of the platforms were only erected in 2014.

In general, we observed Great Gray Owls nesting in diverse tree and structure types. The majority of our stick nests were in lodgepole pines and snag nests were in Douglas firs, which is consistent with previous observations of Great Gray Owl nests in the Greater Yellowstone Ecosystem (Franklin 1988, Whitfield and Gaffney 1997). Great Gray Owls preferred old stick nests and broken off snags for nesting sites, although they used other structures including mistletoe and man-made nesting platforms. Whitfield and Gaffney (1997) suggested that Great Gray Owls were shifting to a reliance on stick nests (91% of nests) because of fewer available old-growth snags due to age and firewood production. We documented more nests in stick nests than both previous studies, indicating that the results of Whitfield and Gaffney (1997) may have been a product of small samples size. We observed that nest success was lower in snags versus stick nests, perhaps indicating that broods are more vulnerable in these more exposed nesting structures. Future studies using remote monitoring of nest sites could help determine causes of nest failures and differences in success between nesting substrates. Further, trees in which snag nests were located were generally atypical of the forest stands in which they were located. Snags were typically much older than the forest stands and availability of these structures may decrease over time.

We measured nest site habitat characteristics in 2 different ways; with on-the-ground measurements and using remote sensing and GIS. Both techniques resulted in similar results for canopy cover at nest sites, but were significantly different for measures of distance to meadow. Several studies emphasize the importance of meadows proximal to nest sites for foraging and, thereby, nest success (e.g., Winter 1986). However, Wu et al. (2015) noted that 10 out of 47 nest sites were farther than 750 m from the nearest meadow.

Using a 30 m GIS land cover layer, we measured mean distance-to-meadow for non-riparian nest sites at 218 m, while the mean was 49 m for on-the-ground measurements. Most meadows measured at the nest site were smaller than 30 m x 30 m and would not be classified as meadows by remote layers. Also, we regularly observed owls foraging within forest patches, and distance to meadow did not come out as a significant variable in our predictive models of breeding season habitat. The scale at which meadows are measured obviously affects the significance of this variable. More detailed studies of microhabitat use within a territory using high frequency relocations of breeding male Great Gray Owls are needed to assess the size and type of meadow habitat that may be most important for foraging and nest site selection.

The mean elevation of Great Gray Owl nests was 2,052 m (range 1,850-2,404 m), indicating that owl nests generally occurred at low to mid-elevation coniferous forest habitat. Franklin (1988) observed a similar mean elevation of 2,078 m for nesting Great Gray Owls in Idaho and Wyoming. However, we also located a few nests in lower elevations in the Snake River corridor in our study area. Wu et al. (2015) also recently noted Great Gray Owls nesting in lower elevation hardwood habitats in California. Future studies should survey "atypical" breeding habitats, such as riparian areas, because of the nesting plasticity exhibited across studies.

The models we created to predict breeding habitat within Jackson Hole corroborated our measurements of nest site characteristics, indicating that owls are selecting for older aged forests (using vegetation height as a proxy for age) with higher canopy cover that are further from roads in areas with lower elevation and slope. While habitat characteristics at the nest are important, foraging habitat and habitat composition within a territory may play a more important role in nesting density and demographics (Duncan 1997). Researchers using 95% MCPs to estimate territory size have inferred that Great Gray Owls do not defend territories (e.g., Bull and Henjum 1988). However, we found no overlapping of adjacent territorial owls at the 75% KDE level, suggesting that owls are defending their territories at this level (75% KDE for breeding owls corresponds to a 514-m radius surrounding the nest site). KDEs from non-breeding adults also indicated direct avoidance of neighboring nesting territories.

Models of nesting habitat are useful for predicting nesting areas, but may be limited without incorporation of some measure of patch size (Laberson et al. 1994). For example, our models predicted many areas of good habitat that occurred at spatial scales not suitable for raptor nesting (i.e., too small patch size). We incorporated a measure of patch size by refining the model to assess the percentage of all cells within a 500-m radius of each cell that also fell within the top 10% of predicted habitat ("good habitat"). We then eliminated cells that had less than 50% of the surrounding cells as "good habitat". This gave a conservative estimate of areas that were predicted as "good habitat" in a patch size large enough to host a territory (based on our 75% KDE from breeding owls). Using this metric, we estimated that up to 103 potential Great Gray Owl nest territories may currently exist in Jackson Hole (see Figure 8). However, there may be finer scale habitat variables that drive owl nest site selection that we did not measure or attempt to model.

All but one Great Gray Owl tracked during our study moved to areas of lower elevation in the winter months, as has been noted in other radio-tracking studies (Bull et. al 1988). This shift in seasonal habitat use and selection can be seen in both the KDEs (see Tables 2 and 3) and the habitat models. Owls are selecting areas in riparian habitats with meadows that are closer to roads at lower elevations during the winter. Our models did not predict any winter habitat surrounding or within the northern half of the Jackson Hole region, including the Gros Ventre drainage. The highest proportion of winter habitat measured occurred within the Snake River Drainage south of Moose, Wyoming. This finding is corroborated by the fact that all but 1 marked owl in this study moved to discrete winter ranges within predicted winter habitat. This was consistent for the 2 marked owls that have summer ranges in the northern part of the valley and up the Gros Ventre drainage, traveling 52.5 and 25.0 km to winter range, respectively. However, our winter habitat models are largely based on 1 year with a limited sample size of locations and should be viewed as a preliminary model for this population. More work is needed to validate and refine models of winter habitat in Wyoming.

Great Gray Owls dispersed to lower elevations in winter, presumably because these areas had less snow and greater prey availability, which was also reported by van Riper and van Wagtendonk (2006) and Franklin (1987). Selection for areas of lower snowpack meant that owls tended to occupy areas nearer to roads. This can become a mortality hazard, as we attributed 50% of documented mortalities to be vehicle strikes in the winter months. Because of limited available winter habitat, most owls wintered in 1 of 3 locations within the Snake River drainage. There are other reports of Great Gray Owls grouping up in the winter (Patla, personal communication), and we observed as many as 15 individual owls in 1 day within a 3-km stretch of river bottom.

In the late fall and winter, several groups of hatch-year Great Gray Owls from different broods were regularly observed together, forming a semi-colonial wintering strategy for young Great Gray Owls. We did not observe Great Gray Owl pairs wintering together. In general, individuals returned to the same nesting territories each year. However, we recorded 1 instance when a breeding female died and no birds nested at that site the following year. We also observed 1 nest where the same breeding male returned to nest with a new female (we do not know the fate of the previous breeding female). We also observed several breeding males visiting other known Great Gray Owl territories in the early spring (February) before settling on their territory from the previous year. A few weeks after fledglings left the nest, males assumed sole responsibility for feeding the chicks as females dispersed from territories. Females were then observed visiting neighboring Great Gray Owl territories on numerous occasions. Once fledglings dispersed in late September and early October, we observed breeding pairs back on territories, visiting nest sites, and displaying courtship behaviors before separating again for the winter. We propose that owls may be strengthening pair bonds and selecting nest sites in the fall for the following spring.

The majority of our winter movement data are based on observations during one winter. However, our findings indicate that studying a larger sample size of radio-tagged Great Gray Owls over more years is important to further understand the family group dynamics, social interactions, and crucial winter habitat requirements of Great Gray Owls. More tracking data are also needed from fledgling owls to determine natal dispersal, winter range associations, mortality, and movement dynamics during the sub-adult phase.

Our modeling results highlight several aspects of Great Gray Owl biology with significant management implications. First, Great Gray Owls are selecting summer habitat of older-aged forests with higher canopy cover. We also believe that patch size plays an important role in nest placement but further studies on the scale of patch selection are needed. Counter to general assertions in the literature, we did not find that owls were selecting for meadows. However, most previous studies are not based on detailed investigations of habitat use and selection from radio-marked owls. We regularly observed owls foraging within closed canopy forests, but we also generally located owls during the day. Also, the majority of nests were located in sticks nests, presumably mostly constructed by Northern Goshawks based on size and characteristics. Further work is needed to understand the relationship and reliance on species such as Northern Goshawks for owl nest sites. Though our results indicated nests are not limiting this population, a significant reduction in goshawks or snag availability may impact future populations of Great Gray Owls.

Based on our preliminary models of winter habitat, we found winter habitat is greatly limited within our study area. The majority of owls were funneled into habitat within the Snake River corridor. Human populations are also attracted to these habitats which can significantly impact future Great Gray Owl winter habitat. While we did find Great Gray Owls inhabiting low density housing areas, the effects of occupying these areas are unknown. Future studies should investigate potential differences in survival rates and breeding success of owls from wintering areas with varying levels of anthropogenic disturbance.

Long-term changes to habitat may also be affecting the reproductive success of Great Gray Owls in western Wyoming. Changes in prey availability can significantly reduce overall body condition in owls, which has been shown to affect clutch size (e.g., Korpimaki and Hakkarainen 1990, Durant et al. 2010). Increasing development within the modeled winter range may have reduced overall prey populations or adversely changed small mammal community assemblages already. Attraction to areas with available, abundant primary prey species (pockets gophers and voles) may explain why we observed concentrations of Great Gray Owls during the winter months.

In addition to potential anthropogenic impacts during the winter, climate change likely also has and will affect Great Gray Owls in this region. Snow cover has been melting earlier in recent years due to climate change and increasing spring temperatures in western Wyoming (Hall et al. 2015), which may increase foraging habitat in the pre-nesting period. However, changing temperatures may also cause an increase in crust hardness during the late spring months (Kausrud et al. 2008). Great Gray Owls typically hunt by plunging into snow to capture prey, and increased crust hardness may lead to decreased prey capture rates (Kausrud et al. 2008), thereby reducing female body condition and clutch size. Further, increased temperatures can advance the timing of avian nesting, but nest productivity can decrease if nesting does not coincide with the timing of peak prey availability (Lehikoinen 2010). Understanding how long-term climate trends may affect the timing of nest initiation, foraging in the pre-nesting period, prey abundance and availability, seasonal movements, and persistence of nesting habitat for Great Gray Owls is essential to manage for the long-term viability of Great Gray populations in Wyoming.

This study provides the basis for long-term research and management for Great Gray Owls in Wyoming. The magnitude of territories and nest sites located from this study provides a base for long-term monitoring, and our models provide a clear direction for locating additional nest sites. Further, the summer habitat model can be used by managers to estimate the effects of cumulative wildfire effects, future forest treatments, and changes for forest structure because of disease and insect outbreaks.

Because the Great Gray Owl is a long-lived species that specializes on fluctuating prey species such as voles, long-term monitoring is essential to truly assess population health. This study has created models of habitat selection by breeding owls, but more data are needed on a fine-scale habitat use within territories. Our study investigated habitat selection at a landscape level using course scale satellite imagery. Understanding how habitat selection and habitat/prey interactions within a territory may be limiting density and productivity is critical to understanding apparent declines in fledging success.

We suggest that future research also focus on effects of climate change on Great Gray Owl habitat, prey, and their interaction in Wyoming. Longer duration studies are needed on winter habitat use and the potential influence of spring snow conditions on female condition and productivity. Finally, studies on survival and dispersal of young owls are needed in light of the low observed productivity rates in this study.

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LITERATURE CITED

Beyer, H. L. 2004. Hawth's Analysis Tools for ArcGIS. www.spatialecology.com/htools.

Bloom, P. H., W. S. Clark, and J. W. Kidd. 2007. Capture techniques. Pages 193-220 *in* Raptor Research Techniques (D. M. Bird and K. L. Bildstein, Editors). Hancock House Publishers, Surrey, British Columbia, Canada.

Bull, E. L., and J. R. Duncan. 1993. Great Gray Owl (*Strix nebulosa*). *In* The Birds of North America, Number 41 (A. Poole and F. Gill, Editors). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Bull, E. L., and M. G. Henjum. 1990. Ecology of the Great Gray Owl. US Department of Agriculture, Forest Service, General Technical Report PNW-GTR-265. Pacific Northwest Research Station, Portland, Oregon, USA.

Bull, E. L., M. G. Henjum, and R. S. Rohweder. 1988a. Nesting and foraging habitat of Great Gray Owls. Journal of Raptor Research 22:101-106.

Bull, E. L., M. G. Henjum, and R. S. Rohweder. 1988b. Home range and dispersal of Great Gray Owls in northeastern Oregon. Journal of Raptor Research 22:101-106.

Bull, E. L., M. G. Henjum, and R. S. Rohweder. 1989c. Reproduction and Mortality of Great Gray Owls in Oregon. Northwest Science 63:38-43.

Chomko, S. A. 1990. Identification of North American rodent teeth. Pages 72-99 *in* Mammalianosteology (B. M. Gilbert, Editor). Columbia: Missouri Archaeological Society.

Craighead, J. J., and F. C. Craighead Jr. 1969. Hawks, Owls, and Wildlife. Dover Publications, New York, New York, USA.

Cramp, S. 1985. Handbook of the Birds of Europe, the Middle East and North Africa, Volume 4. Oxford University Press.

Duncan, J. R. 1992. Influence of prey abundance and snow cover on Great Gray Owl breeding dispersal. Dissertation. University of Manitoba, Winnipeg, Canada.

Duncan, J. R. 1997. Great Gray Owls (*Strix nebulosa)* and forest management in North America: review and recommendations. Journal of Raptor Research 31:160-166.

Duncan, J. R., and P. A. Duncan. 1997. Increased distribution records of pwl species in Manitoba based on a volunteer nocturnal survey using Boreal Owl (*Aegolius funereus*) and Great Gray Owl (*Strix nebulosa*) playback. *In* Biology and Conservation of Owls of the Northern Hemisphere: Second International Symposium (J. R. Duncan, D. H. Johnson, and T. H. Nicholls, Editors). US Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-190. Saint Paul, Minnesota, USA.

Duncan, J. R., and P. H. Hayward. 1994. Review of technical knowledge: Great Gray Owls. Pages 159-175 *in* Flammulated, Boreal, and Great Gray Owls in the United States: A Technical Conservation Assessment (G. D. Hayward and J. Verner, Technical Editors). US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-253. Fort Collins, Colorado, USA.

Durant, J. M., J. P. Gendner, and Y. Handrich. 2010. Behavioural and body mass changes before egg laying in Barn Owl: cues for clutch size determination? Journal of Ornithology 151:11-17.

Elbroch, M. 2006. Animal Skulls. A Guide to North American Species. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Fetz, T. W., S. W. Janes, and H. Lauchstedt. 2003. Habitat characteristics of Great Gray Owl sites in the Siskiyou Mountains of southwestern Oregon. Journal of Raptor Research 37:315-322.

Forsman, E. D. 1981. Molt of the Spotted Owl. Auk 98:735-742.

Francis, C. M., and M. S. W. Bradstreet. 1997. Monitoring boreal forest owls in Ontario using tape playback surveys with volunteers. Pages 175-184 *in* Biology and Conservation of Owls of the Northern Hemisphere: Second International Symposium (J. R. Duncan, D. H. Johnson, and T. H. Nicholls, Editors). US Department of Agriculture, Forest Service, North Central forest Experiment Station, General Technical Report NC-190. Saint Paul, Minnesota, USA.

Franklin, A. B. 1988. Breeding biology of the Great Gray Owl in southeastern Idaho and northwestern Wyoming. Condor 90:689-696.

Hall, D. K., C. J. Crawford, N. E. DiGirolamo, G. A. Riggs, and J. L. Foster. 2015. Detection of earlier snowmelt in the Wind River Range, Wyoming, using Landsat imagery, 1972-2013. Remote Sensing of Enviornment 162:45-54.

Hilden, O., and P. Helo. 1981. The Great Gray Owl *Strix nebulosa* – a bird of the northern tiaga. Ornis Fennica 58:159-166.

Ibarra, J. T., K. Martin, T. A. Altamirano, F. H. Vargas, and C. Bonacic. 2014. Factors associated with the detectability of owls in South American temperate forests: implications for nocturnal raptor monitoring. Journal of Wildlife Management 78:1078-1086.

Kausrud, K. L., A. Mysterud, H. Steen, J. O. Vik, E. Ostbye, B. Cazelles, E. Framstad, A. M. Eikeset, I. Mysterud, T. Solhoy, and N. C. Stenseth. 2008. Linking climate change to lemming cycles. Nature 456:93-97.

Korpimaki, E., and H. Hakkarainen. 1991. Fluctuating food supply affects the clutch size of Tengmalm's owls independent of laying date. Oecologia 85:543-552.

Lamberson, R. H., B. R. Noon, C. Voss, and K. S. McKelvey. 1994. Reserve design for territorial species: the effects of patch size and spacing on the viability of the Northern Spotted Owl. Conservation Biology 8:185-195.

Lane, W. H., D. E. Andersen, and T. H. Nicholls. 1997. Distribution, abundance, and habitat use of territorial male Boreal Owls (*Aegolius funereus)* in northeastern Minnesota. Pages 246-247 *in* Biology and Conservation of Owls of the Northern Hemisphere: Second International Symposium (J. R. Duncan, D. H. Johnson, and T. H. Nicholls, Editors). US Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-190. Saint Paul, Minnesota, USA.

Lehikoinen, A., E. Ranta, H. Peitiäinen, P. Byholm, P. Saurola, J. Valkama, O. Huitu, H. Henttonen, and E. Horpimäki. 2010. The impact of climate and cyclic food abundance on the timing of breeding and brood size in four boreal owl species. Oecologi 165:349-355.

Marti, C. D., M. Bechard, and F. M. Jaksic. 2007. Food habits. Pages 129-149 *in* Raptor Research and Management Techniques, Second Edition (K. L. Bildstein and D. M. Bird, Editors). Raptor Research Foundation, Hancock House Publishers, Blaine, Washington, USA.

Mayr, E., and M. Mayr. 1954. The tail molt of small owls. Auk 172-178.

Nero, R. W. 1980. The Great Gray Owl – Phantom of the Northern Forest. Smithsonian Institution Press, Washington, D.C., USA.

Palmer, D. A. 1987. Annual, seasonal, and nightly variation in calling activity of Boreal and Northern Saw-whet Owls. Pages 162-168 *in* Biology and Conservation of Northern Forest Owls: Symposium Proceedings, 1987 February 3-7, Winnipeg, MB (R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre, Editors). US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-142. Fort Collins, Colorado, USA.

Patla, S. M. 1997. Nesting ecology and habitat of the Northern Goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Thesis. Idaho State University, Pocatello, USA.

Pullianianen, E., and K. Loisa. 1977. Breeding biology and food of the Great Gray Owl, *Strix nebulosa*, in northeastern Finish forest upland. Aquilo Ser Zoologica 17:23-33.

Reid, M. E. 1989. The predator-prey relationships of the Great Gray Owl in Yosemite National Park. Cooperative National Parks Resources Studies Unit, Technical Report Number 35. University of California, Davis, USA.

Rogers, K., Y. A. Girard, C. Stermer, L. Woods, B. Barr, and C. K. Johnson. 2014. Avian Trichomonosis in Great Gray Owls and California Spotted Owls. TWS Western Symposium: Wildlife Diseases and Pathology. Annual Meeting of The Western Section of The Wildlife Society: Contributed Papers.

Rognan, C. B., J. M. Szewczak, and M. L. Morrison. 2009. Vocal individuality of Great Gray Owls in the Sierra Nevada. Journal of Wildlife Management 73:755-760.

Pauli, J., B. Bedrosian, and N. Osterberg. 2004. Effects of blowdown on small mammal populations. American Midland Naturalist 156:151-162.

Quintana-Coyer, D. L., R. P. Gerhardt, M. D. Broyles, J. A. Dillon, C. A. Friesen, S. A. Godwin, and S. D. Kamrath. 2004. Survey protocol for the Great Gray Owl within the range of the northwest forest plan. USDA/BLM/DOI Technical Report. BLM-Instruction Memorandum Number OR-2004-50.

Sears, C. L. 2006. Assessing distribution, habitat suitability, and site occupancy of Great Gray Owls (*Strix nebulosa*) in California. Thesis. University of California, Davis, USA.

Seber, G. A. E. 1982. The Estimation of Animal Abundance. Second Edition. Hafner, New York, New York, USA.

Stepnisky, D. P. 1997. Landscape features and characteristics of Great Gray Owl (*Strix nebulosa*) nests in fragmented landscapes of central Alberta. Pages 601-607 *in* Biology and Conservation of Owls of the Northern Hemisphere: Second International

Symposium (J. R. Duncan, D. H. Johnson, and T. H. Nicholls, Editors). US Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-190. Saint Paul, Minnesota, USA.

Sulkava, S., and K. Huhtala. 1997. The Great Gray Owl (*Strix nebulosa*) in the changing forest environment of northern Europe. Journal of Raptor Research 31:151-159.

Suopajärvi, P., and M. Suopajärvi. 1994. Lapinpöllön iän määrittäminen. (English summary: Ageing of Great Grey Owls) Linnut 29:2/1994 27-30.

United States Department of Agriculture. 2015. Natural Resources Conservation Science SNOTEL data. www.wcc.nrcs.usda.gov/snow (accessed 31 August 2015).

van Ripper, III, C., J. J. Fontaine, and J. W. van Wagtendonk. 2013. Great Gray Owls (*Strix nebulosa*) in Yosemite National Park: on the importance of food, forest structure, and human disturbance. Natural Areas Journal 33:286-295.

van Ripper III, C., and J. van Wagtendonk. 2006. Home range characteristics of Great Gray Owls in Yosemite National Park, California. Journal of Raptor Research 40:130-141.

Whitfield, M. B., and M. Gaffney. 1997. Great Gray Owl (*Strix nebulosa*) breeding habitat use within altered forest landscapes. *In* Biology and Conservation of Owls of the Northern Hemisphere: Second International Symposium (J. R. Duncan, D. H. Johnson, and T. H. Nicholls, Editors). US Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-190. Saint Paul, Minnesota, USA.

Winter, J. 1986. Status, distribution, and ecology of the Great Gray Owl (*Strix nebulosa*) in California. Thesis. San Francisco State University, San Francisco, California, USA.

Wintle, B. A., R. P. Kavanagh, M. A. McCarthy, and M. A. Burgman. 2005. Estimating and dealing with detectability in occupancy surveys for forest owls and arboreal masupials. Journal of Wildlife Management 69:905-917.

Wu, J. X., R. B. Siegel, H. I. Loffland, M. W. Tingley, S. I. Stock, K. N. Roberts, J. J. Keane, J. R. Meadley, R. Bridgman, and C. Stermer. 2015. Diversity of Great Gray Owl nest sites and nesting habitats in California. Journal of Wildlife Management 79:937-947.

Wyoming Game and Fish Department. 2010. State Wildlife Action Plan. Wyoming Game and Fish Department, Cheyenne, USA.

POPULATION ESTIMATE FOR BLACK-BACKED WOODPECKERS (*PICOIDES ARCTICUS*) IN THE BLACK HILLS OF SOUTH DAKOTA AND WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Black-backed Woodpecker

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: 1 March 2015 – 30 June 2016

PERIOD COVERED: 1 March 2015 – 20 June 2015

PREPARED BY: Elizabeth Matseur, University of Missouri – Columbia

SUMMARY

We distributed 124 Black-backed Woodpecker (*Picoides arcticus*) transects across the Black Hills in South Dakota (*n* = 100) and Wyoming (*n* = 24; Figures 1 and 2). Of the total 124 transects, 120 had 10 points each, 1 transect had 9 points, 2 transects had 8 points, and 1 transect had 7 points, resulting in 1,232 total point counts and 3,696 individual point counts. We conducted 3 rounds of point counts for Black-backed Woodpeckers between 1 April and 28 June 2015. In Wyoming's portion of our study area, the 24 transects had a total of 240 points. In rounds 1, 2, and 3 of the point counts across the entire study area, we detected 143, 89, and 68 Black-backed Woodpeckers, respectively for a total of 300 Black-backed Woodpecker detections. In Wyoming's portion during rounds 1, 2, and 3, we detected 9, 6, and 9 Black-backed Woodpeckers, respectively.

Special thank you to all that provided housing for the 2015 Field Crew. Thank you to Mary Reedy for arranging housing in Hill City, SD, Tony Balistreri and Rhonda Obyrne for arranging housing in Nemo, SD, and Dee McCarthy for arranging housing in Custer State Park.

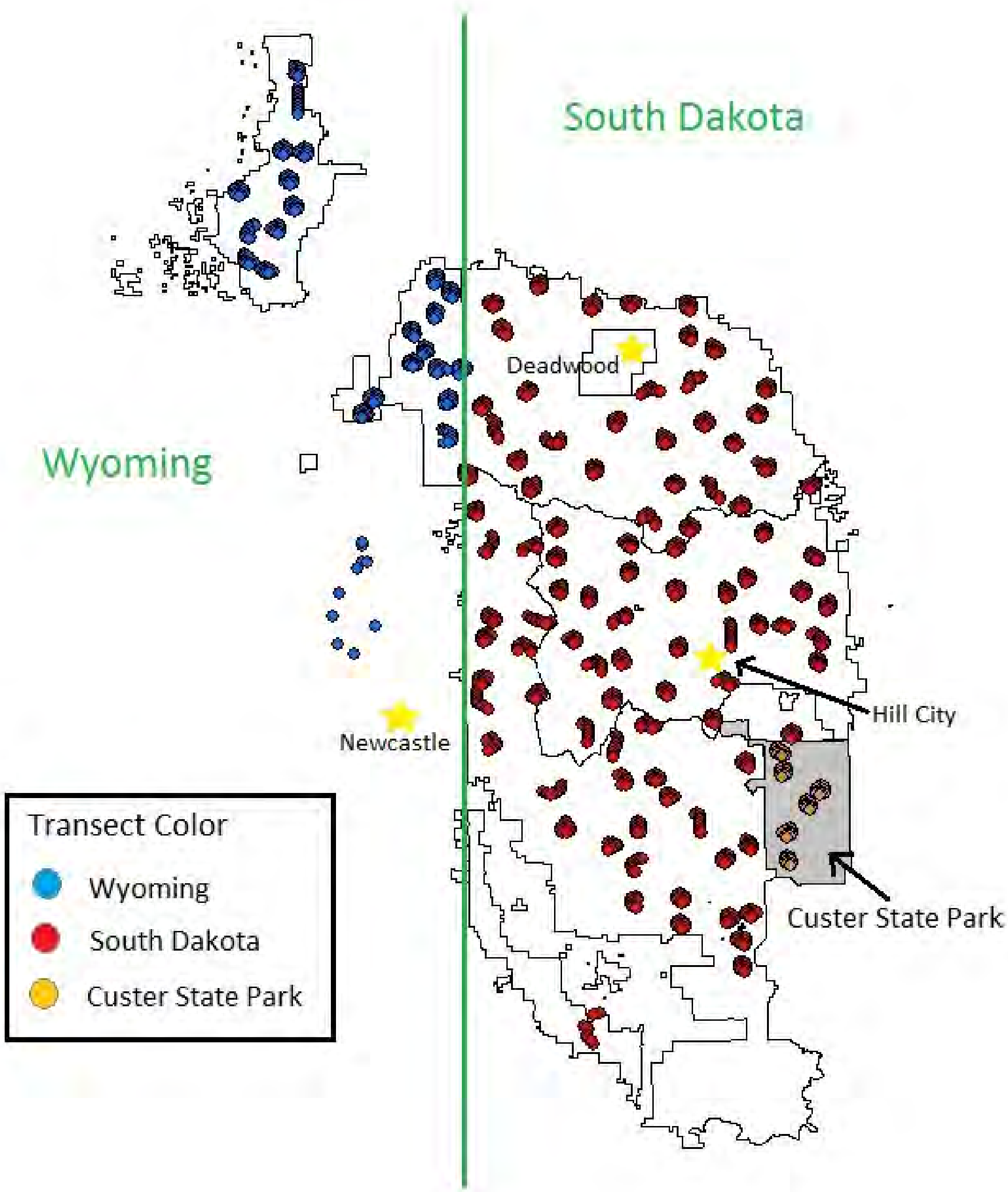


Figure 1. Locations of the 124 Black-backed Woodpecker (*Picoides arcticus*) transects we distributed across the Black Hills in South Dakota (*n* = 100) and Wyoming (*n* = 24).

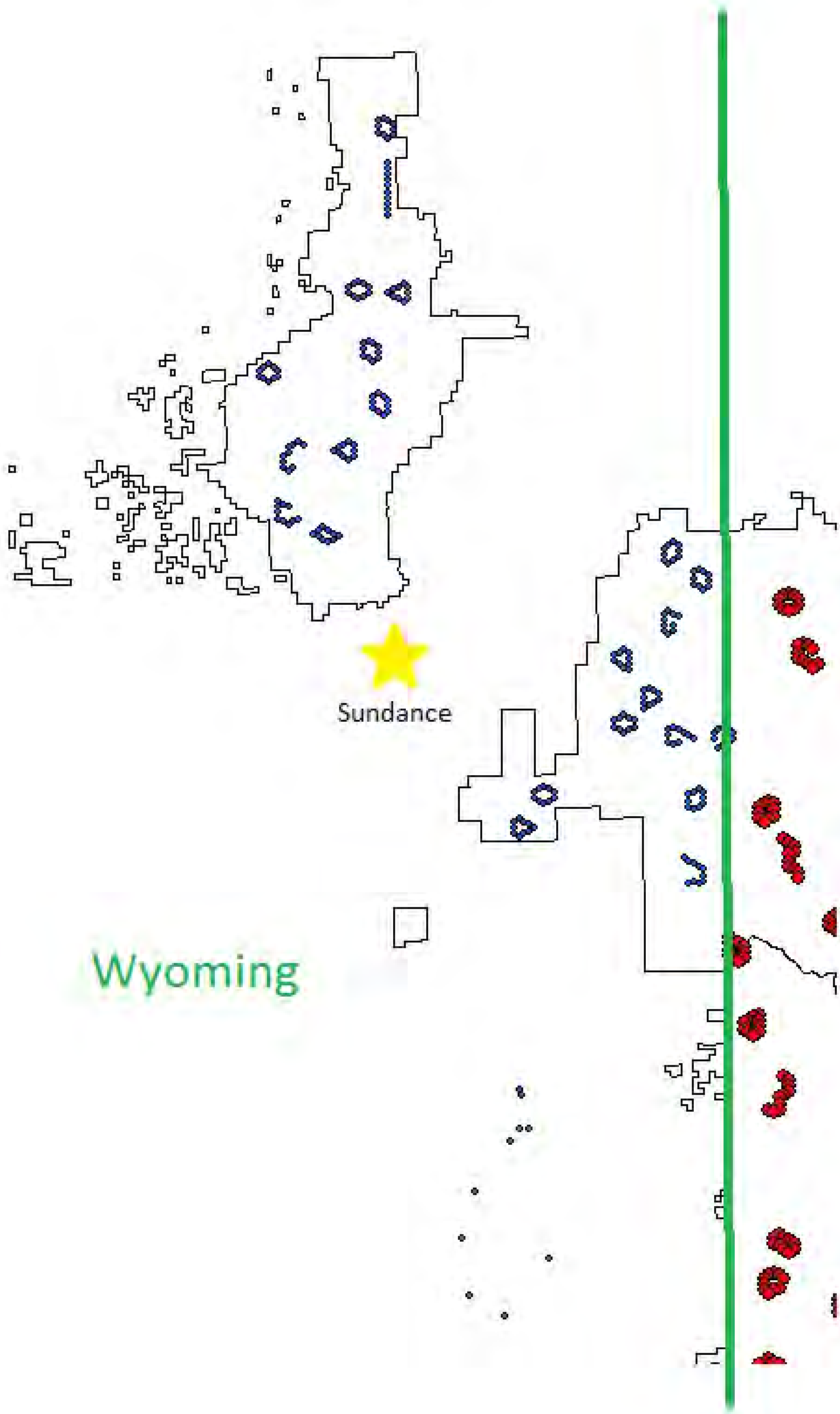


Figure 2. Locations of the 24 Black-backed Woodpecker (*Picoides arcticus*) transects we distributed in the Wyoming portion of our study area in the Black Hills.

MECHANISTIC STUDY OF SONGBIRD ENERGY DEVEOPMENT IMPACTS

STATE OF WYOMING

NONGAME BIRDS: Nongame Birds

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: 22 October 2013 – 30 June 2016

PERIOD COVERED: 4 May 2015 – 31 March 2016

PREPARED BY: Lindsey Sanders, Wyoming Cooperative Fish and Wildlife Research Unit
Dr. Anna Chalfoun, Wyoming Cooperative Fish and Wildlife Research Unit

SUMMARY

The objectives of our project during this reporting period are to: 1) Continue monitoring sagebrush songbird reproductive success across natural gas well density gradients; 2) Test alternative hypotheses for increased rodent nest predator abundance with increased natural gas well densities (including potential impacts on rodents from a mesopredator release and food availability); 3) Examine the spatial and temporal consistency in the relationship between nest predation and natural gas development; 4) Evaluate small mammal abundance across our established energy development gradient using a rigorous trapping and mark-recapture regime to determine whether previous activity indices reflect actual differences in rodent abundance; and 5) Test alternative hypotheses to investigate potential mechanisms driving small mammal abundance (including potential impacts on rodents from a mesopredator release and food availability).

The summer 2015 field season ran from 4 May through 28 August. Our field crew consisted of 1 Master's student (Lindsey Sanders) and 5 field technicians. During the field season, we implemented the following field methodologies: songbird nest searching, camera monitoring of songbird nests, small mammal trapping, scent station monitoring of mesopredators, raptor point counts, and nest vegetation surveys. We completed all field data collection on schedule, and all data have been entered into a database management system and proofed. We began some exploratory analyses of trends in nest survival, small mammal abundance, and predator abundance, and presented our preliminary analyses in a poster session at the Wyoming Chapter of The Wildlife Society annual meeting in December 2015.

We are continuing our preliminary analyses of 2014 and 2015 data, which include: songbird daily nest survival rates; captures per 100 trap nights for all small mammal species; activity indices for mesopredators (coyotes, badgers, raptors); body condition indices for deer

mice; and analysis of giving-up density experimental results. We completed video review of all predation events caught on camera in 2015. Lindsey Sanders presented her research proposal for graduate work at a Wyoming Game and Fish Department seminar, and had her research proposal approved by her graduate committee. Technicians for the 2016 summer field season have been hired, and additional planning for the field season is currently underway. We are currently coordinating two undergraduate research projects for summer 2016 which will provide additional insight into our research questions.

GUARD HAIR IDENTIFICATION OF SHREWS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Shrews

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2014 – 30 June 2016

PERIOD COVERED: 1 July 2014 – 30 June 2016

PREPARED BY: Daniel Pinneo, Shrew Biologist
Tasha L. Bauman, Forensic Analyst
Zack Walker, Statewide Nongame Bird and Mammal Program Supervisor
Nichole Bjornlie, Nongame Mammal Biologist

SUMMARY

Shrews (*Sorex* spp.) are small, mainly insectivorous mammals of the family Soricidae and constitute 10% of the mammalian diversity in Wyoming. In Wyoming, 5 species of shrews are classified as Species of Greatest Conservation Need (SGCN), pygmy shrew (*S. hoyi*; NSS2-Tier II), dwarf shrew (*S. nanus*; NSS3-Tier II), Preble's shrew (*S. preblei*; NSS3-Tier II), Hayden's shrew (*S. haydeni*; NSS4-Tier II), and vagrant shrew (*S vagrans*; NSS4-Tier II; WGFD 2010). All are considered rare and only occur in relatively small, disjunct populations (WGFD 2010). An additional 4 species are classified as nongame: western water shrew (*S. navigator*), masked shrew (*S. cinereus*), Merriam's shrew (*S. merriami*), and dusky shrew (*S. monticolus*). Due to their inability to disperse long-distances, shrews are susceptible to extirpation as a result of habitat loss and degradation resulting from leading wildlife conservation challenges. These challenges include climate change and disruption of historic disturbance regimes, as well as bark-beetle outbreaks, wildfires, logging, and incompatible grazing practices. In addition, shrews are often found in close association with other nongame and SGCN (e.g., voles [*Microtus* spp.] and chipmunks [*Tamias* spp.]) and, therefore, may serve as a good indicator species for assessing impacts of habitat changes, including those due to climate change.

Although small mammal trapping surveys were conducted in various habitats by the Wyoming Game and Fish Department (Department) in the 1990s, these surveys produced few records of shrews. In fact, <50 records for shrews listed as SGCN exist in the Department's Wildlife Observation System. Shrews are found throughout the state and in a variety of habitats, typically near riparian systems or other damp areas (WGFD 2010). For example, the Hayden's shrew is found only in the Black Hills, an area of special concern, as these populations are

isolated from other populations in Wyoming. This may lead to the population displaying limited connectivity and may give them the highest potential for listing as a Distinct Population Segment (WGFD 2010).

Given the difficulty in locating and indentifying species of shrews, the Department developed a manual (Appendix A) to aid in the identification of the 9 species of shrews that are found throughout Wyoming using nonlethal methods. The information that was collected includes morphological characteristics and photos of different trap sites that give the researcher an idea of the habitat of which the species inhabit. Pictures of the hairs are also included for each species to give a representation of what the hairs look like microscopically, as well as maps of the geographical distribution of each species.

In Moore et al. (1974), 5 species of shrews were described in detail. In this publication, those 5 species are again described to expand on the research in that publication. Extensive research was conducted to include some key characteristics and include the other 4 species of shrews that are located in Wyoming.

Museum specimens were used to collect guard hairs from ≥10 individuals of each species of shrew in Wyoming. Three of the species (*S. vagrans*, *S. palustris*, and *S. cinereus*) came from the University of Wyoming Vertebrate Museum. The rest of the species were collected through a collaborative processes that included multiple organizations, museums, and universities. For a complete list of the collaborators in this project, please refer to page 9 of the manual (Appendix A).

During our research, *S. palustris* was the only 1 of the 9 species that stood out as easily identified microscopically. The other 8 species show very similar characteristics microscopically, and we were unable to separate them out to species by using guard hair identification.

LITERATURE CITED

Moore, T. D., L. E. Spence, C. E. Dugnolle, and W. P. Hepworth. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Department Bulletin 14, Wyoming Game and Fish Department, Cheyenne, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Appendix A. *Sorex* hair identification manual.

Wyoming Game and Fish Department

Sorex
Hair Identification
Manual

Wagonhound Creek trap site.

Shrew that was trapped at Wagonhound

2

Sorex Hair Identification Manual

By

Daniel Pinneo (Shrew Biologist)
Tasha L. Bauman (Forensic Analyst)
Zack Walker (Statewide Nongame Bird and Mammal Program Supervisor)
Nichole Bjornlie (Nongame Mammal Biologist)

edited by
Tasha L. Bauman

Wyoming Game and Fish Department
2015

Rock Creek Trap Site

Introduction

Shrews are small, mainly insectivorous mammals of the family Soricidae, and constitute 10% of the mammalian diversity in Wyoming. In Wyoming, 5 species of shrews are classified as Species of Greatest Conservation Need (SGCN), pygmy shrew (Sorex hoyi; NSS2-Tier 2), dwarf shrew (S. nanus; NSS3-Tier2), Preble's shrew (S. preblei; NSS3-Tier2), Hayden's shrew (S. haydeni; NSS4-Tier2), and vagrant shrew (S. vagrans; NSS4-Tier2; WGFD 2010). All are considered rare and only occur in relatively small, disjunct populations (WGFD 2010). An additional four species are classified as nongame western water shrew (S. navigator), masked shrew (S. cinereus), Merriam's shrew (S. merriami), dusky shrew (S. monticolus). Due to their inability to disperse long-distances, shrews are susceptible to extirpation as a result of habitat loss and degradation resulting from leading wildlife conservation challenges. These Challenges include climate change and disruption of historic disturbance regimes, as well as bark-beetle outbreaks, wildfires, logging, and incompatible grazing practices. In addition, shrews are often found in close association with other nongame and SGCN (e.g., voles and chipmunks) and therefore may serve as a good indicator species for assessing impacts of habitat changes, including those due to climate change.

Although small mammal trapping surveys were conducted in various habitats by the Wyoming Game and Fish Department (Department) in the 1990's, these surveys produced few records of shrews. In fact, < 50 records for shrews listed as SGCN exist in the Wildlife Observation System (WOS). Shrews are found throughout the state and in a variety of habitats, typically near riparian systems or other damp areas (WGFD 2010). For example, the Hayden's shrew is found only in the Black Hills, an area of special concern, as these populations are isolated from other populations in Wyoming. This may lead to the population displaying limited connectivity and may give them the highest potential for listing as a Distinct Population Segment (WGFD 2010).

The information included in this manual is to aid in the identification of the nine species of shrews that are found throughout Wyoming using nonlethal methods. The information that was collected includes morphological characteristics, photos of different trap sites (that give the researcher an idea of the habitat of which the species inhabit). Pictures of the hairs are also included, for each species, to give a representation of what the hairs look like microscopically, as well as maps of the geographical distribution of each species.

In Moore et al. 1974 five species of shrews were described in detail. In this publication those five species are again described to expand on the research in the Moore et al. publication. Extensive research was conducted to include some key characteristics and include the other four species of shrews that are located in Wyoming.

Museum specimens were used to collect guard hairs from ≥10 individuals of each species of shrew in Wyoming. Three of the species (Sorex vagrans, Sorex palustris, and Sorex cinereus) came from the University of Wyoming Vertebrate Museum. The rest of the species were collect through a collaboration processes that included multiple organizations, museums and universities. For a complete list of the collaborator in this project, please refer to page 9.

During our research the Sorex palustris, was the only of the nine species, which stood out as easily identified microscopically. The other eight species show very similar characteristics microscopically and, we were unable to separate them out by species using guard hair identification.

North Laramie River Trap Site

Location Descriptions

Wagonhound Creek: the trap site is just south of Douglas. An unknown Sorex species was trapped at this location.

North Laramie River: the trap site is along the Garret Road near Garret. Sorex *monticolus* and an unknown Sorex species were trapped at this location.

Fort Laramie: the trap site is on the Fort Laramie National Historic Site. An unknown Sorex species was trapped at this location.

Friend Creek: the trap site is near Laramie Peak right next to the Friend Park Campground. Sorex *monticolus*, Sorex *nanus*, and an unknown Sorex species were trapped at this location.

Lodgepole Creek: the trap site is east of Laramie near the Lincoln Head Memorial near the Happy Jack Recreation area. Sorex *cinereus* and Sorex *monticolus* were trapped at this location.

Rock Creek: the trap site, this creek is the one that runs through Rock River. Sorex *nanus* was trapped at this location.

Table of Contents

Organizations where samples were collected

Wyoming Game and Fish Department
Department Headquarters
5400 Bishop Blvd
Cheyenne, WY 82006

University of Wyoming Vertebrate Museum
Elizabeth Wommack, staff curator and manager of the vertebrate collection, Berry Biodiversity Conservation Center,
1000 E. University Ave. Laramie, WY 82071

Sam Noble Oklahoma Museum of Natural History
Department of Mammals and Oklahoma collections of Genomic Resources, Brandi Coyner, Curatorial Associate
The University of Oklahoma, 2401 Chautauqua,
Norman, OK 73072-7029

University of Central Oklahoma Natural History Museum
Biology Department Lynda Loucks Collections Manager
100 N. University Dr., Box 89, Edmond, OK 73034

Denver Museum of Nature and Science
Biology Department Jeff Stephenson, Collections Manager
2001 Colorado Blvd, Denver, CO 80205

Smithsonian Institution National Museum of Natural History
Patuxent Wildlife Research Center Suzanne Peurach Collections Manager
PO Box 37012, MRC 111; Washington, DC, 20013-7012

Natural History Museum of Utah
Vertebrate Zoology Collections, Eric Rickart, Curator of vertebrate Zoology
301 Wakara Way, Salt Lake City, UT 84108

University of Montana Zoological Museum
Paul Hendricks Ph.D., Philip L. Wright Zoological Museum,
University of Montana, 32 Campus Dr., Missoula, MT 59812

University of Washington Burke Museum
Jeff Bradley, Mammology Collections Manager Burke Museum
Box 353010, University of Washington, Seattle, WA 98195-3010

University of Colorado Museum of Natural History
Emily Braker, Vertebrate Collections Manager, University of Colorado at Boulder Zoology Section 265 UCB Boulder, CO 80309-0265

Lodgepole Creek Trap Site

Definitions

Band: a pronounced change in color that separates adjacent areas.

Not Banded

Figure 1. No distinct change in color just fades into the next color.

Banded

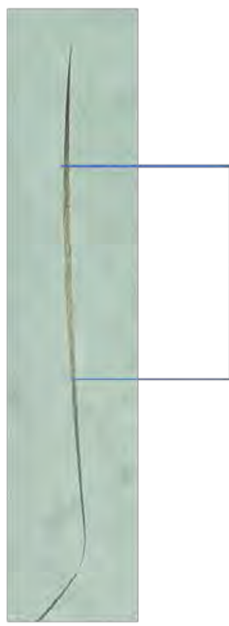


Figure 2. Distinct color change that is abrupt

Moore et al. 1974

Definitions

<u>Diameter:</u> the width that was take to determine the diameter listed in the descriptions, the spot that was used was the widest spot on the hair (not including portions that were crushed) this measurement was in micrometers (um).

<u>Dorsal Guard Hair:</u> The elastic, horny, large, shiny outer coat fibers from the mid-dorsal region of the back which give animals their characteristic coloring appearance.

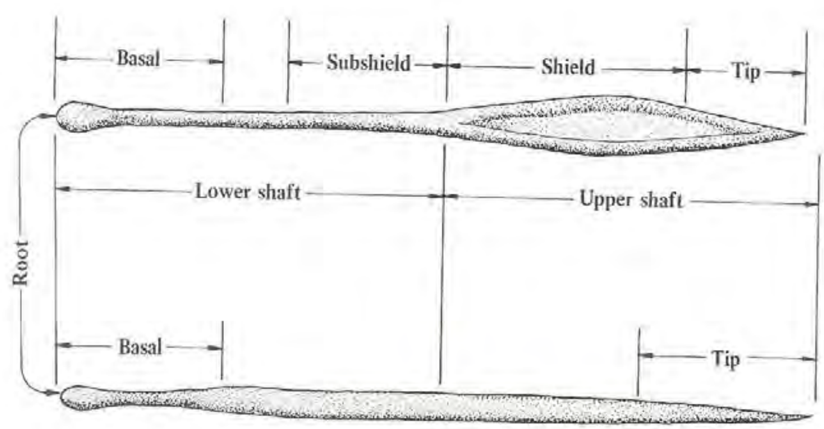
<u>Hair length:</u> the length of the entire hair including all regions of the hair. This measurement was in millimeters (mm).

Moore et al. 1974

Regions of the Hair

Hair Regions: the different locations on the hair.

Basal end: the area of the hair that contains the root end of the hair.
Lower Shaft: the lower half of the hair that contains the basal end, and the sub-shield region.
Shield: the area of the hair that is wider than other parts of the hair but is right below the tip of the hair.
Tip: the opposite end of the hair than the basal end, ends in a point, but can be blunt if the tip of the hair has been cut.
Upper shaft: the top half of the hair that contains the shield and the tip.



Moore et al. 1974

Definitions

Medulla: the central portion of the hair that is composed of a series of discrete cells or a amorphous spongy mass.

Medulla configurations: the appearance of the medulla.

- **Absent:** there is no medulla present, usually at the basal end of the hair for Shrews.
- **Uniserial ladder:** a single column of discrete cells that is separated by a clear gap.
- **Clear uniserial ladder:** same as uniserial ladder except for the what would be normal black cells the cells are somewhat clear.

Scales: the pattern of the outer layer of the hair. That appears to be regular and irregular, shingle-like, clear cells with different configurations. (To view this aspect of the hair, we applied fingernail polish to a slide and placed the hair in it and let it dry over night).

Moore et al. 1974

Root End Shapes

Root Shape: the shape of the root end portion of the hair.

Ball shape root: similar to the wine-glass shape but more shaped in the form of a ball

Slightly tapered root: a shape that forms a "J" shape but some times is pulled straight when collecting samples.

Figure 7. Ball Shaped Root end

Figure 6. Slightly tapered root end

Moore et al. 1974

Scale Margin Distance

<u>Scale Margin Distance:</u> the distance between consecutive scale, can be close, intermediate, or distant.

Figure 3.
Close

Figure 4.
Intermediate

Figure 5.
Distant

Moore et al. 1974

Scale Margin Types

Scale Margin Types: the different configurations of edges of the scales.

Margins smooth: they have no abrupt irregularities.

Margins crenate: have a saw-tooth type appearance, that are shallow.

Figure 8. Margins Smooth

Figure 9. Margins Crenate

Moore et al. 1974

Scale Patterns

Scale Pattern: the different variations in the pattern of the scales.

Coronal: scales that are shaped like a crown each scale completely encircles the hair shaft.

Regular petal: overlapping scales that are very close to lower petals and uniform in size and shape.

Regular wave: scales that do not overlap, wavy appearance, continuous, and with the waves and the crests on, one scale compared to the next are the same.

Figure 10. Coronal

Figure 11. Regular Petal

Figure 12. Regular Wave

Moore et al. 1974

Strictures

Strictures: a narrowing of the hair in a region with pronounced reduction in the diameter of the shaft, as well as where the hair tends to bend.

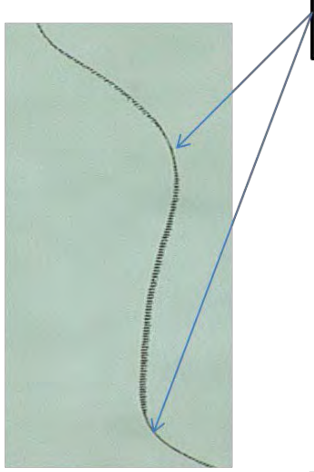


Figure 13. Lower Shaft Strictures

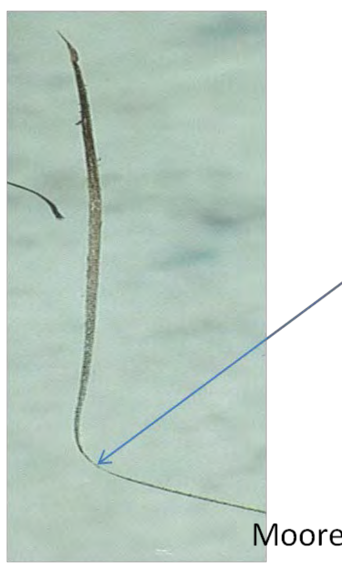


Figure 14. Subshield Stricture

Moore et al. 1974

Friend Creek Trap Site

Sorex species

- Sorex *cinereus:* Cinereus Shrew or Masked Shrew, 20 specimens were sampled.
- Sorex *haydeni:* Prairie Shrew, 10 specimens were sampled.
- Sorex *hoyi: Pygmy Shrew,* 19 specimens were sampled.
- Sorex *merriami:* Merriam's Shrew, 19 specimens were sampled.
- Sorex *monticolus:* Montane Shrew, 20 specimens were sampled.
- Sorex *nanus:*, Dwarf Shrew, 18 specimens were sampled.
- Sorex *palustris:* Water Shrew, 20 specimens were sampled.
- Sorex *vagrans:* Vagrant Shrew, 20 specimens were sampled.
- Sorex *preblei:* Preble's Shrew, 14 specimens were sampled.

Sorex *cinereus*
(Cinereus Shrew or Masked Shrew)

Color Arrangement: Dark Brown tip, followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white (figure 15).

Banded or not: Banded (figure 15)

Length: The upper end that was observed was 7.05mm and the lower end that was observed was 3.41 mm. The average of all hair sampled was 4.53 mm.

Diameter: the upper end of the observed diameter was 39.43 um. The lower end of the observed diameter is 23.89 um. The average observed diameter was 29.96 um.

Shield: upper shaft (figure 5)

Subshield and Shaft strictures: 3 to 5

Basal Medulla: absent to uniserial ladder (figure 16-17)

Shield Medulla: clear uniserial ladder, possibly changing to normal uniserial ladder towards the tip of the hair.

Basal Scales: coronal to regular petal, with margins that are smooth and distant
(figures 19-21).

Shield Scales: regular wave with margins that are smooth and intermediate to crenate and intermediate (figure 22)

Root shape: Slightly tapered root (figure 16&19).

Sorex *cinereus*
Color and Medulla Pictures

Figure 15. Sorex *cinereus* color
Magnification 175X

Figure 16. S. *cinereus* root tip and basal end medulla
Magnification 175X

Figure 17. S. *cinereus* shaft medulla
Magnification 175X

Figure 18. S. *cinereus* full hair with a green line that is 1 mm.
Magnification 100X

Sorex *cinereus*
Scale Cast Pictures

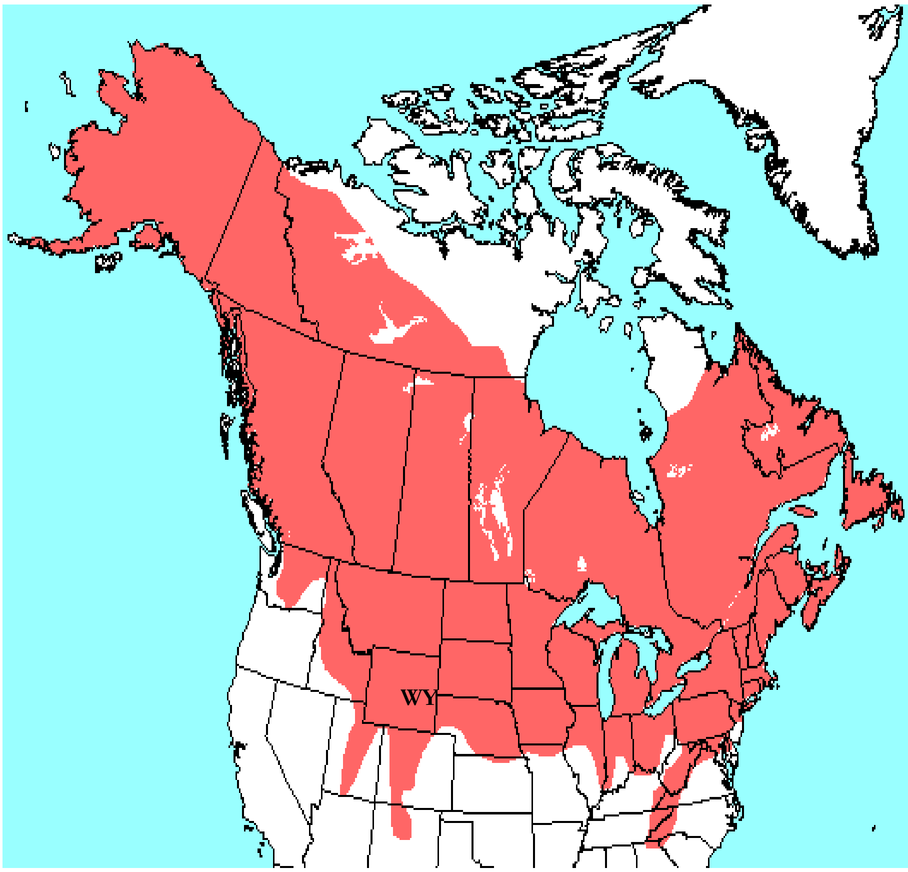
Figure 19. root tip scale cast
Magnification 400x

Figure 20. lower shaft scale cast
Magnification 400x

Figure 21. upper shaft scale cast
Magnification 400x

Figure 22. shield scale cast
Magnification 400x

Sorex *cinereus* Distribution



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Sorex *haydeni*
(Prairie Shrew)

Color Arrangement: may have a white tip, to dark brown tip, followed by a light brown band mid shield fading to a gray lower shield to basal end, basal end is white.

Banded or not: Banded

Length: The upper end of the observed hair length was 5.70 mm. the lower end observed length was 2.94 mm. the average observed hair length was 3.70 mm.

Diameter: the upper end of the observed hair diameter was 35.08 um. The lower end of the observed hair diameter was 24.84 um. The average observed hair diameter was 29.63 um.

Shield: upper shaft

Subshield and Shaft strictures: 2-5

Basal Medulla: absent to uniserial ladder

Shield Medulla: uniserial ladder

Basal Scales: coronal to regular petal with margins that are smooth and distant

Shield Scales: regular wave with margins that are smooth or somewhat crenate and intermediate to crenate and intermediate

Root shape: Slightly tapered root

Sorex *haydeni*
Color and Medulla Pictures

Figure 24. S. *haydeni* root tip and basal end medulla
Magnification 175X

Figure 23. Sorex *haydeni* hair color
Magnification 175X

Figure 25. S. *haydeni* shaft medulla
Magnification 175X

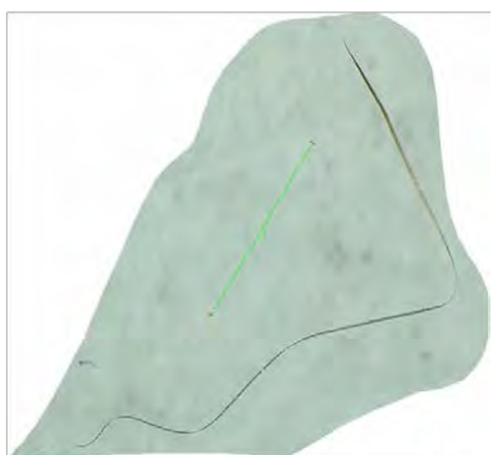


Figure 26. S. *haydeni* full hair with green line = 1 mm
Magnification 100X

Sorex *haydeni*
Scale Cast Pictures

Figure 27. root tip scale cast
Magnification 400x

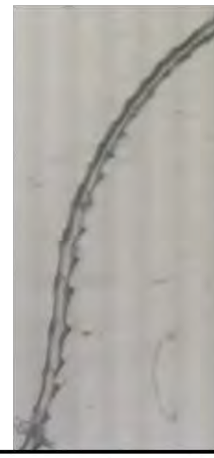


Figure 28. lower shaft scale cast
Magnification 400x

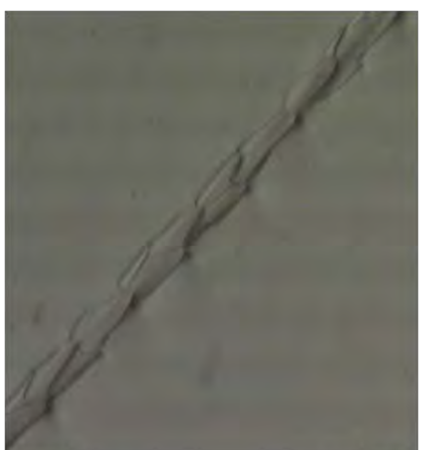
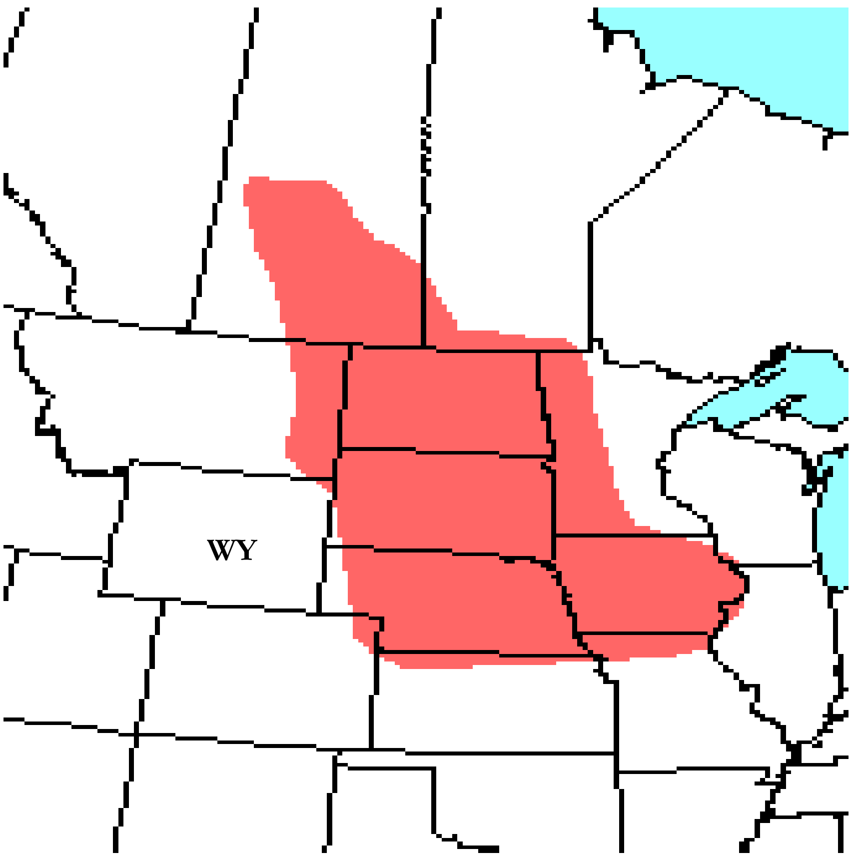


Figure 29. upper shaft scale cast
Magnification 400x

Figure 30. shield scale cast
Magnification 400x

Sorex *haydeni* Distribution



Sorex *hoyi*
(Pygmy Shrew)

Color Arrangement: Dark brown tip (could have a white tip followed by a dark brown upper shield), followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white.

Banded or not: Banded

Length: the upper end of the observed hair length was 5.31 mm. the lower end of the observed hair length was 2.08 mm. the average observed hair length was 3.40 mm.

Diameter: the upper end of the observed hair diameter was 30.50 um. The lower end of the observed hair diameter was 13.78 um. The average observed hair diameter was 24.95 um.

Shield: upper shaft

Subshield and Shaft strictures: 2-5

Basal Medulla: absent to uniserial ladder

Shield Medulla: clear or normal uniserial ladder

Basal Scales: coronal to regular petal with margins that are smooth and distant

Shield Scales: regular wave with margins that are smooth and intermediate to crenate and intermediate

Root shape: slightly tapered root

Sorex *hoyi*
Color and Medulla Pictures

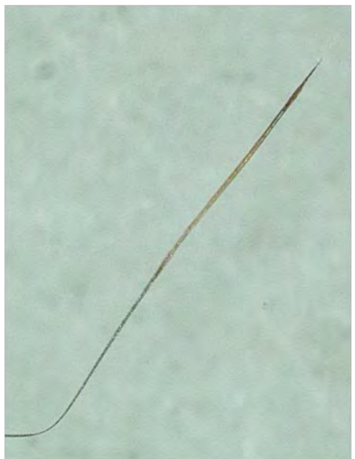


Figure 31. Sorex *hoyi* hair color
Magnification 175X

Figure 32. root tip and basal end medulla
Magnification 175X

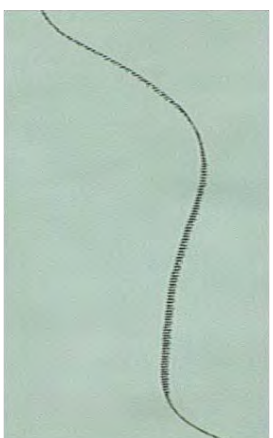


Figure 33. mid shaft medulla
Magnification 175X

Figure 34. full hair with green line = 1 mm
Magnification 50X

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Sorex *hoyi*
Scale Cast Pictures

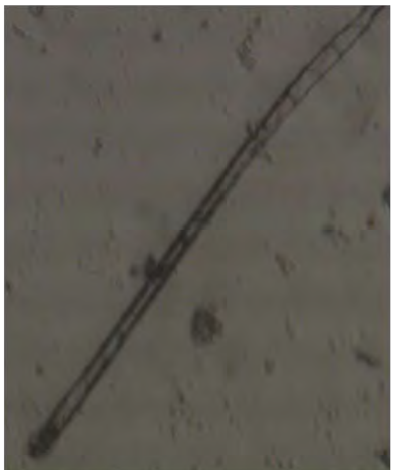
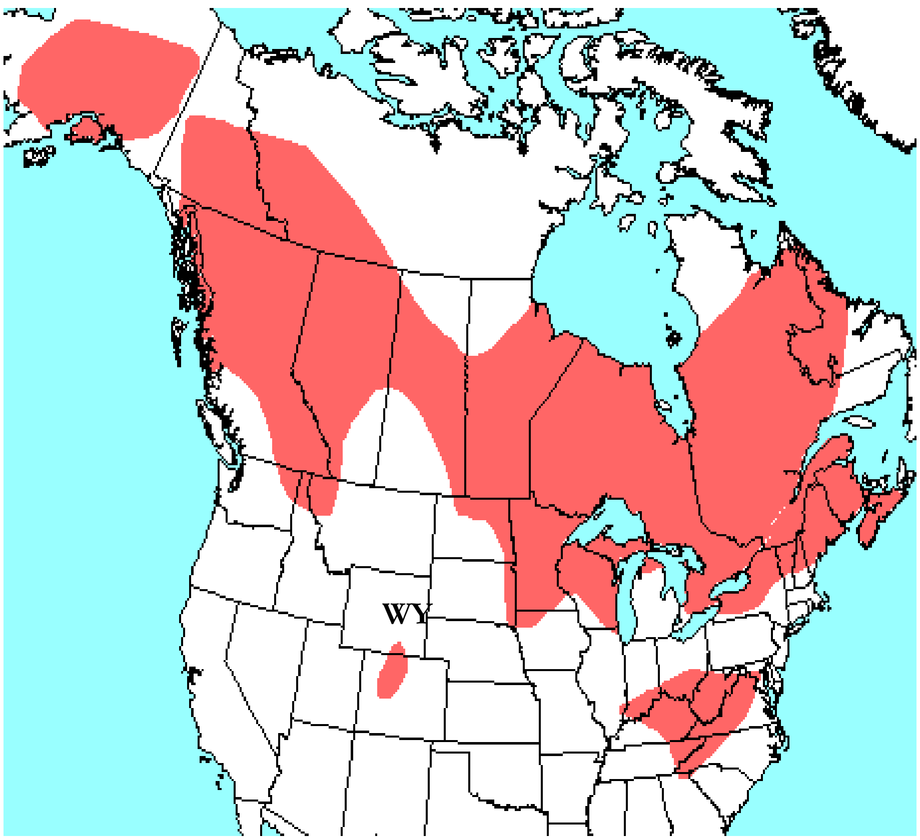


Fig.5 root tip scale cast
Magnification 400x

Fig.7 shield scale cast
Magnification 400x

Fig.6 mid shaft scale cast
Magnification 400x

Sorex *hoyi* Distribution



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Sorex *merriami*
(Merriam's Shrew)

Color Arrangement: white tip, dark brown upper shield, followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white.

Banded or not: banded

Length: the upper end of the observed hair length was 4.95 mm. the lower end of the observed hair length was 3.25 mm. the average observed hair length was 4.37 mm.

Diameter: the upper end of the observed hair diameter was 51.30 um. The lower end of the observed hair diameter was 18.74 um. The average observed hair diameter was 25.98 um.

Shield: upper shaft

Subshield and Shaft strictures: 2-4

Basal Medulla: absent to uniserial ladder

Shield Medulla: normal to clear uniserial ladder or clear uniserial ladder

Basal Scales: coronal to regular petal with margins that are smooth and distant

Shield Scales: regular wave with margins that are smooth and intermediate to crenate and intermediate

Root shape: slightly tapered root

Sorex *merriami*
Color and Medulla Pictures

Fig.1 Sorex *merriami* hair color
Magnification 175X

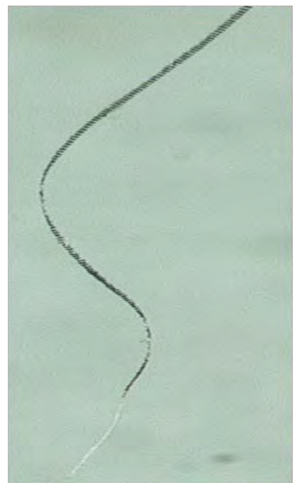

Fig.2 root tip and basal end medulla
Magnification 175X

Fig.3 mid shaft medulla
Magnification 175X

Fig.4 Full hair with green line = 1 mm
Magnification 50X

Sorex *merriami*
Scale Cast Pictures

Figure 35. root tip scale cast
Magnification 400x

Figure 36. mid shaft scale cast
Magnification 400x

Figure 37. shield scale cast
Magnification 400x

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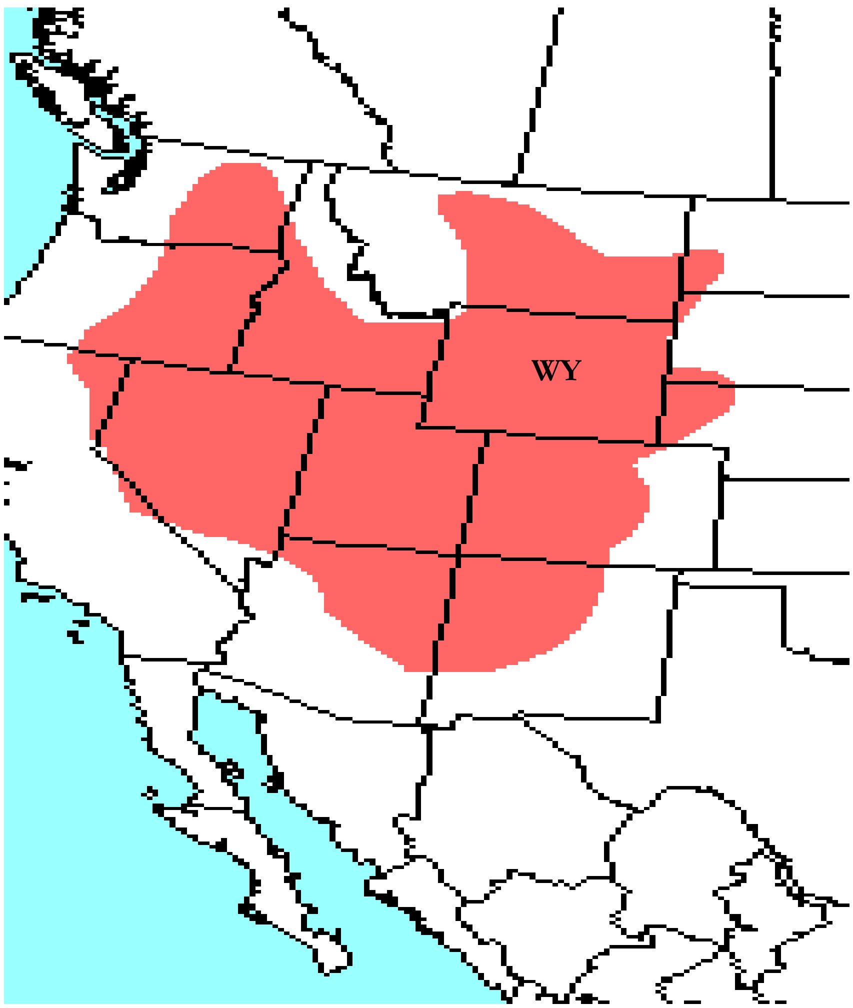
Sorex *merriami* Distribution



Sorex *monticolus*
(Montane Shrew)

Color Arrangement: Dark brown tip, followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white.

Banded or not: Banded

Length: the upper end of the observed hair length was 4.88 mm. the lower end of the observed hair length was 3.12 mm. the average observed hair length was 4.20 mm.

Diameter: the upper end of the observed hair diameter was 34.93 um. The lower end of the observed hair diameter was 17.73 um. The average observed hair diameter was 26.26 um.

Shield: Upper Shaft

Subshield and Shaft strictures: 2-4

Basal Medulla: absent to uniserial ladder

Shield Medulla: clear uniserial ladder to normal uniserial ladder

Basal Scales: coronal to regular petal with margins that are smooth and distant

Shield Scales: regular wave with margins that are smooth and intermediate

Root shape: ball shaped root tip

Sorex *monticolus*
Color and Medulla Pictures

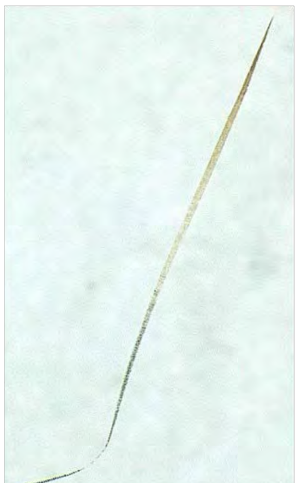


Figure 38. Sorex *monticolus* hair color
Magnification 175X

Figure 39. root tip and basal end medulla
Magnification 175X

Figure 40. mid shaft medulla
Magnification 175X

Figure 41. full hair with green line = 1 mm
Magnification 50X

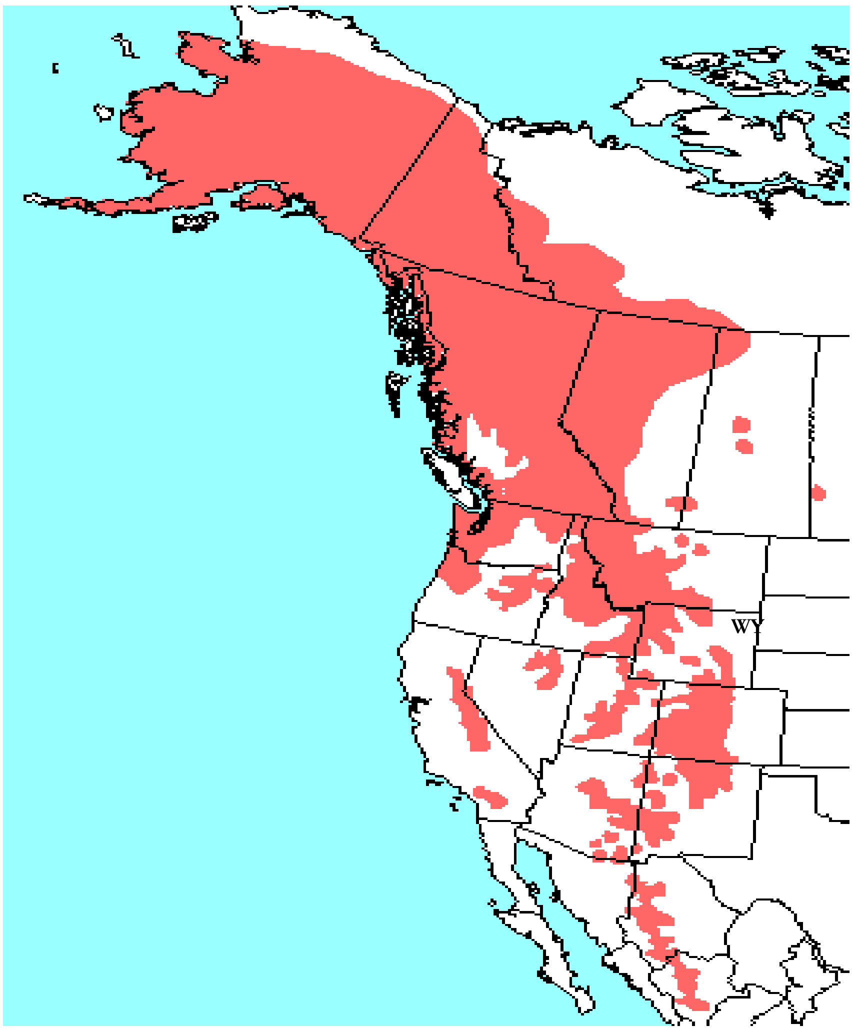
Sorex *monticolus*
Scale Cast Pictures

Figure 42. root tip scale cast Magnification 400x

Figure 43. mid shaft scale cast Magnification 400x

Figure 44. shield scale cast Magnification 400x

Sorex *monticolus* Distribution



Sorex *nanus*
(Dwarf Shrew)

Color Arrangement: White tip, dark brown upper shield, followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white.

Banded or not: Banded

Length: the upper end of the observed hair length was 5.41 mm. the lower end of the observed hair length was 2.80 mm. the average observed hair length was 4.01 mm.

Diameter: the upper end of the observed hair diameter was 33.34 um. The lower end of the observed hair diameter was 18.61 um. The average observed hair length was 24.17 um.

Shield: Upper Shaft

Subshield and Shaft strictures: 2-4

Basal Medulla: absent to uniserial ladder

Shield Medulla: clear uniserial ladder

Basal Scales: coronal to regular petal with margins that are smooth and distant

Shield Scales: regular wave with margins that are smooth and intermediate and some have crenate and intermediate following the smooth and distant.

Root shape: slightly tapered root

Sorex *nanus*
Color and Medulla Pictures

Figure 45. Sorex *nanus* hair color
Magnification 175X

Figure 46. root tip and basal end medulla
Magnification 175X

Figure 47. mid shaft medulla
Magnification 175X

Figure 48. full hair with a green line = 1 mm
Magnification 50X

Sorex *nanus*
Scale Cast Pictures

Figure 49. root tip scale cast Magnification 400x

Figure 50. mid shaft scale cast Magnification 400x

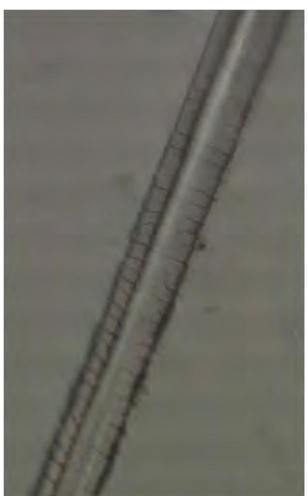
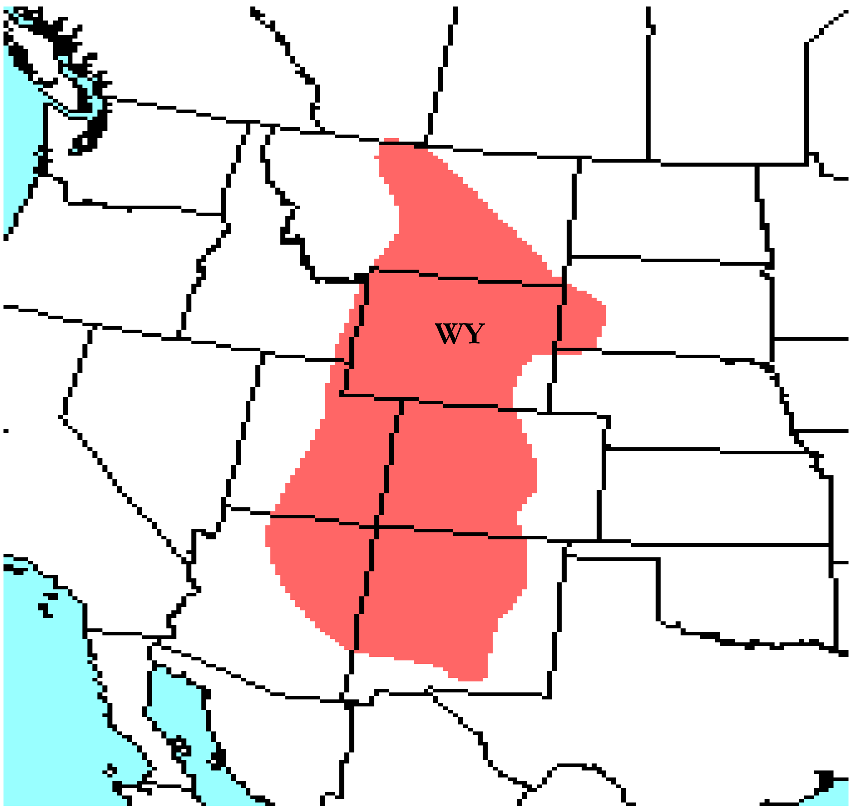


Figure 51. shield scale cast Magnification 400x

Sorex *nanus* Distribution



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Sorex *palustris*
(Water Shrew)

Color Arrangement: White tip, followed by a dark brown bottom of tip and mid shield, fading to a gray lower shield to basal end, basal end is white.

Banded or not: not banded

Length: The upper end of the observed hair length was 7.40 mm and the lower end of the observed hair length was 4.67 mm. the average length of the observed hair was 5.83 mm.

Diameter: the upper end of the observed hair diameter was32.7 um. The lower end of the observer hair diameter was 24.19 um. The average diameter of the observed hair was 29.77 um.

Shield: upper shaft

Subshield and Shaft strictures: 4-6

Basal Medulla: absent to uniserial ladder

Shield Medulla: uniserial ladder but it could possibly be unbroken with cortical intrusions.

Basal Scales: coronal to regular petal with margins that are smooth and distant. The petals are very elongated.

Shield Scales: Regular wave with margins that are smooth and intermediate to crenate and intermediate

Root shape: slightly tapered root.

Sorex *palustris*
Color and Medulla Pictures

Figure 52. Sorex *palustris* hair color
Magnification 175X

Figure 53. root tip and basal end medulla
Magnification 175X

Figure 54. mid shaft medulla
Magnification 175X

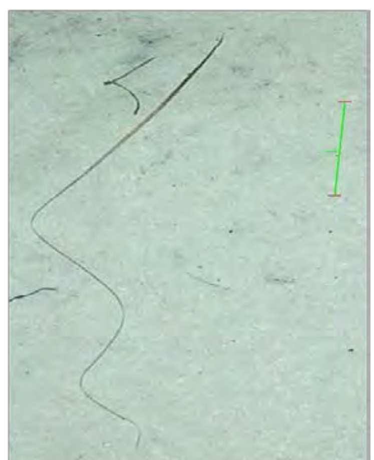

Figure 55. full hair with green line = 1 mm
Magnification 50X

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Sorex *palustris*
Scale Cast Pictures

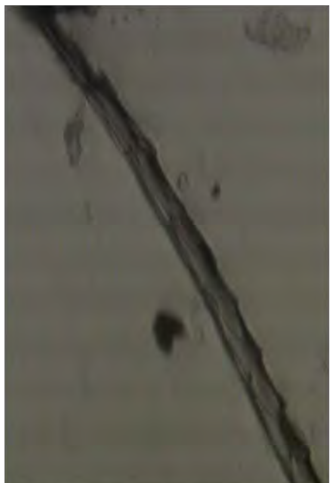


Figure 56. basal end scale cast
Magnification 400x

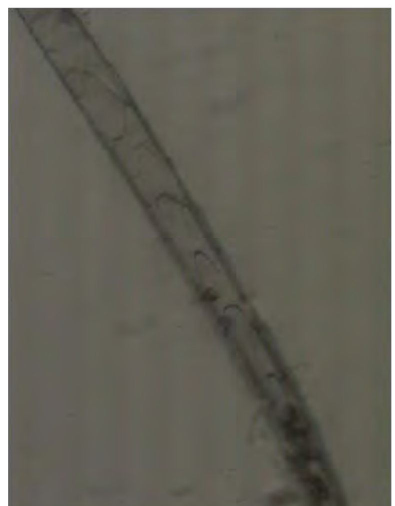


Figure 57. mid shaft scale cast
Magnification 400x

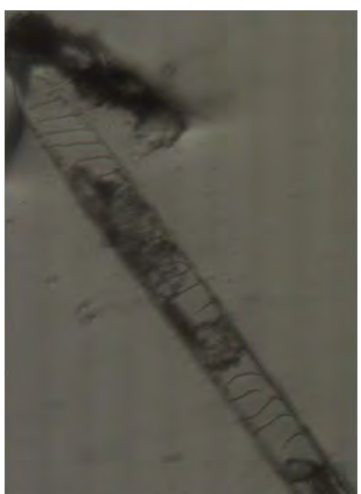
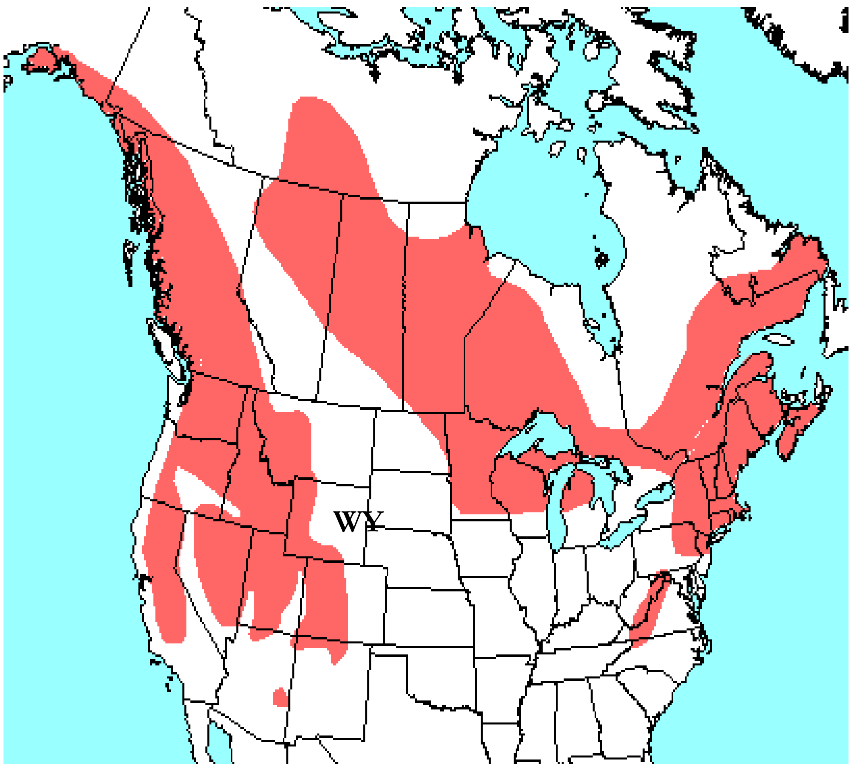


Figure 58. shield scale cast
Magnification 400x

Sorex *palustris* Distribution



Sorex *vagrans*
(Vagrant Shrew)

Color Arrangement: Dark brown tip, followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white.

Banded or not: Banded

Length: The upper end of the observed hair length was 7.53 mm. The lower end of the observed hair length was 3.86 mm. The average of the observed hair length was 5.05 mm.

Diameter: The upper end of the observed hair diameter was 33.86 um. The lower end of the observed hair diameter was 19.73 um. The average of the observed hair diameter was 28.49 um.

Shield: upper shaft

Subshield and Shaft strictures: 2-4

Basal Medulla: absent to fragmental to uniserial ladder

Shield Medulla: uniserial ladder

Basal Scales: coronal, this section is much shorter than the other species, to regular petal with margins that are smooth and distant, very elongated.

Shield Scales: Regular wave with margins that are smooth and intermediate to crenate and intermediate

Root shape: Slightly tapered root

Sorex *vagrans*
Color and Medulla Pictures

Figure 59. Sorex *vagrans* hair color
Magnification 175X

Figure 60. root tip and basal medulla
Magnification 175X

Figure 61. mid shaft medulla
Magnification 175X

Figure 62. full hair and with green line = 1 mm
Magnification 100X

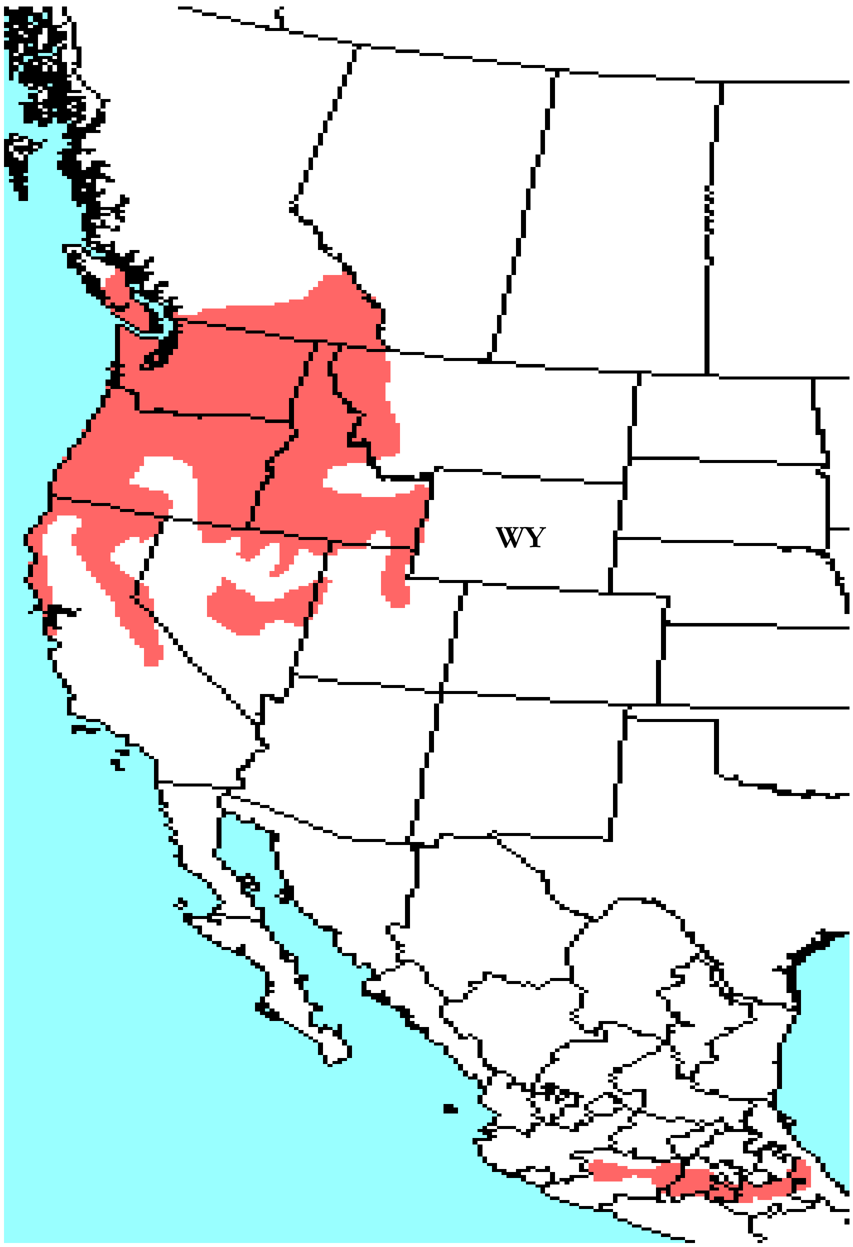
Sorex *vagrans*
Scale Cast Pictures

Figure 63. basal end scale cast
Magnification 400x

Figure 64. mid shaft scale cast
Magnification 400x

Figure 65. shield scale cast
Magnification 400x

Sorex *vagrans* Distribution



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Sorex *preblei*
(Preble's Shrew)

Color Arrangement: dark brown tip, followed by a light brown band mid shield, fading to a gray lower shield to basal end, basal end is white

Banded or not: Banded

Length: The upper end of the observed hair length was 5.46 mm. the lower end of the observed hair length was 2.77 mm. the average observed hair length was 3.69 mm.

Diameter: the upper end of the observed hair diameter was 33.41 um. The lower end of the observed hair diameter was 16.59 um. The average observed hair diameter was 26.13 um.

Shield: Upper Shaft

Subshield and Shaft strictures: 2-5

Basal Medulla: absent to uniserial ladder

Shield Medulla: normal or clear uniserial ladder

Basal Scales: coronal to regular petal with margins that are smooth and distant

Shield Scales: regular wave with margins that are smooth or crenate and intermediate, or smooth to crenate and intermediate.

Root shape: slightly tapered root

Sorex *preblei*
Color and Medulla Pictures

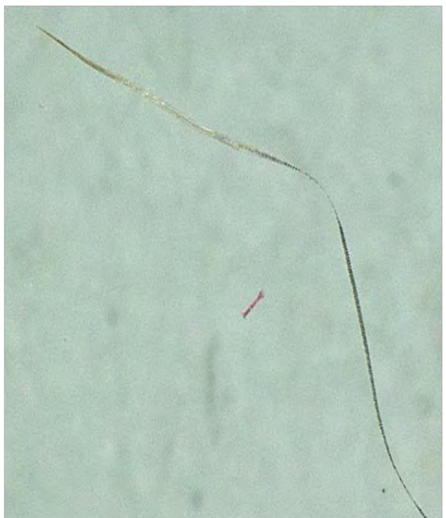


Figure 66. Sorex *preblei* hair color
Magnification 175X

Figure 67. root tip and basal end medulla
Magnification 175X

Figure 68. mid shaft medulla
Magnification 175X

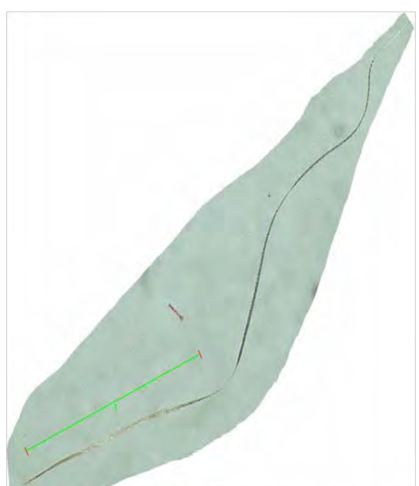


Figure 69. full hair with a green line = 1 mm
Magnification 100X

Sorex *preblei*
Scale Cast Pictures

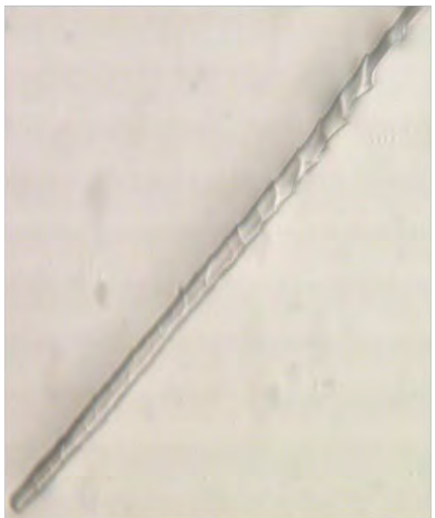


Figure 70. root tip scale cast
Magnification 400x

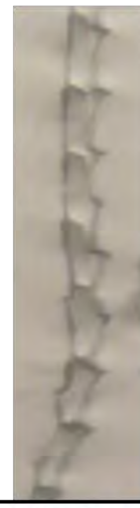


Figure 71. basal end scale cast
Magnification 400x

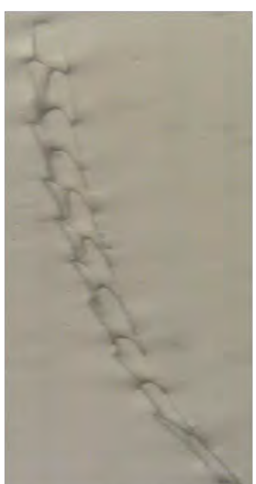
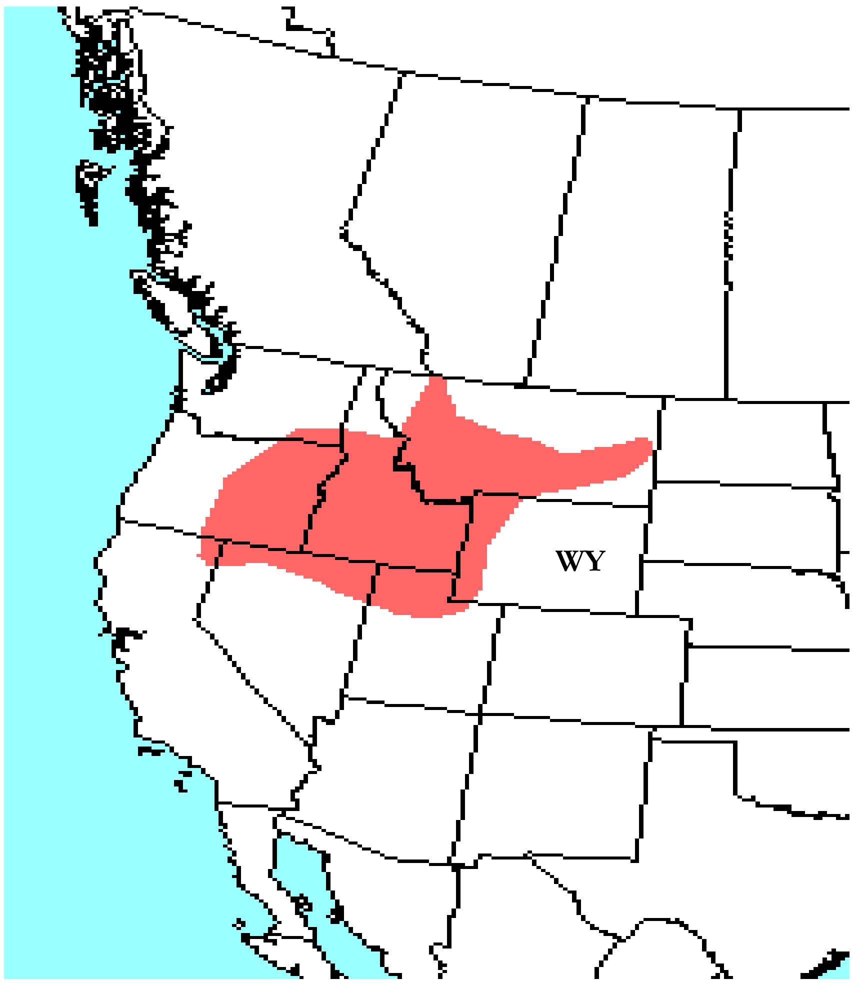


Figure 72. mid shaft scale cast
Magnification 400x

Figure 73. shield scale cast
Magnification 400x

Sorex *preblei* Distribution



Fort Laramie Trap Site

Literature Cited

Moore, T. D., L. E. Spence, C. E. Dugnolle, and W.P. Hepworth. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Department Bulletin 14.

Materials Used

- Compound microscope– was used to see the medulla, root end shape, strictures, and scale cast.
- Electronic compound microscope– was used to see the color of the hair, color bands if any, measured the length and diameter of the hairs, took pictures for the manual for the color and length.
- Electronic ruler on the electronic microscope– used to measure the length and diameter of the hairs.
- Compound microscope with camera attachment– used to take pictures of the scale cast of the hairs.
- Cover slips– size: length 50 mm, width 24 mm and a NO. 1 thickness
- Microscope slides– size: length 75 mm, width 24 mm, thickness 1 mm.
- Finger nail polish– Sally Hansen Hard as Nails, was used to make the cast for the scales casts.
- Histosolve– was used to be able to observe the medulla of the hair.
- Micro-forceps– used to separate the hairs.
- Laboratory notebook– used to record collected data as well as the organizations collected from and the hours spent doing each task.
- Computer– used to create a database for the collected samples, as well as a lab numbering system so the samples could be looked up easily and see what organization they were collected from. Recorded all data from the laboratory notebook as well to create the manual. Created the manual.
- Jump drive

Procedures/Methods

The First step of starting this project was to contact different organizations, museums, and universities (see page 9 for list) to obtain adequate numbers of samples from each species (≥10 see page 21 for number of samples for each species). After all samples were collected the samples were entered into a database and given a lab number to be easily referred back to. The locations on the specimen were the hairs were collected from are the middle of the back guard hairs.

For data collection the hair color was observed under an electronic compound microscope, as well as to gather the length and diameter of the hairs, as well as the pictures of the color. The strictures, medulla, scale cast and root end shape were observed on the compound microscope. The compound microscope with the camera attachment was used to take pictures of the scales, from the scale casts.

The first step in gathering the data was to sort out individual hairs observe which hairs are full with all regions of the hairs intact.

Once a hair is collected the next step is to put a few drops of Histosolve on a microscope slide and drop the hair in it and cover it with a cover slip and look at it under the compound microscope to see what configuration the hair has. This step to you can count the number of strictures the hair has.

The next step is to uncover the hair and let it dry, while its drying place some of the finger nail polish on a different slide and then place the hair in the wet finger nail polish, this will allow the polish to form around the hair, let it set over night. The next day pull the hair out of the polish and place the hair on a slide and cover it to make sure its available for the next step. Now under the compound microscope the scales in the polish should be visible.

The next step is to use the electronic microscope and get the hair color as well as the length and diameter of the hair. The microscope has an electronic ruler so that the length can be collected using the microscope. The diameter of the hair was taken at the widest spot of the hair not including the crushed if any portion. During the whole process record everything in a notebook..

The final step is use the electronic microscope and the compound microscope with the camera attachment to take pictures all the data that was documented.

Index

WYOMING GAME & FISH DEPARTMENT

Conserving Wildlife
Serving People

U.S.
FISH & WILDLIFE
SERVICE

DEPARTMENT OF THE INTERIOR

UNDERSTANDING CHANGING CLIMATE CONDITIONS IN ALPINE HABITATS: A TEST OF WILDLIFE RESPONSES, LIMITS, AND PLASTICITY

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – American pika

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: 1 July 2013 – 30 June 2016

PERIOD COVERED: 1 July 2015 – 18 September 2015

PREPARED BY: L. Embere Hall, Wyoming Cooperative Fish and Wildlife Research Unit
Dr. Anna Chalfoun, Wyoming Cooperative Fish and Wildlife Research Unit

SUMMARY

Contemporary climate change poses one of the biggest challenges to global biodiversity. Shifts in species' distributions and changes in extinction dynamics as a result of new climate conditions have been observed in nearly every ecosystem. In many cases species simply cannot keep up with the rate at which conditions are moving. Behaviors, which are immediately flexible, may provide species with a way to keep pace with warming conditions, but the extent to which species can alter behaviors to deal with climate variability is largely an open question. We examine how well temperature-sensitive animals can buffer warming temperatures through changes in behavior, using the American pika (*Ochotona princeps*) as a model organism.

During the 2015 field season, we completed 10 weeks of data collection in the field, 1 week of laboratory work, and shared preliminary results with an array of audiences. From 1 July-18 September, we sampled 47 individuals (non-invasively), deployed 230 temperature sensors, and recorded 7,000 videos of pika foraging behavior. Preliminary results suggest that pikas may be changing important aspects of when and how they forage, including collecting food at night when temperatures are cooler. We are on track to complete our research within the timelines outlined in our permit proposal, and are excited to collaborate with both professional ecologists and local citizens in our progress.

In mid-summer, we also met with Bridger-Teton National Forest (BTNF) staff to update and coordinate implementation of the BTNF pika-monitoring program that was initiated in 2011. Results of our work will inform ongoing agency efforts to manage wildlife and to prioritize conservation actions in the face of climate change. As changing conditions continue to manifest in western Wyoming and beyond, wildlife conservation activities will be enhanced by anticipating how climate change affects ecological systems, developing a citizenry that is

engaged in science, and understanding how to promote resilience among the most sensitive species. See Appendix A for the complete project summary.

Appendix A. Understanding changing climate conditions in alpine habitats: a test of wildlife responses, limits, and plasticity.

Understanding changing climate conditions in alpine habitats: a test of wildlife responses, limits and plasticity

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Executive Summary

Understanding changing climate conditions in alpine habitats: a test of wildlife responses, limits and plasticity

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Contemporary climate change poses one of the biggest challenges to global biodiversity. Shifts in species' distributions and changes in extinction dynamics as a result of new climate conditions have been observed in nearly every ecosystem. In many cases species simply cannot keep up with the rate at which conditions are moving. Behaviors, which are immediately flexible, may provide species with a way to keep pace with warming conditions, but the extent to which species can alter behaviors to deal with climate variability is largely an open question. We examine how well temperature-sensitive animals can buffer warming temperatures through changes in behavior, using the American pika (*Ochotona princeps*) as a model organism.

During the 2015 field season we completed 10 weeks of data collection in the field, 1 week of laboratory work, and shared preliminary results with an array of audiences. From July 1-Sept 18, we sampled 47 individuals (non-invasively), deployed 230 temperature sensors and recorded 7,000 videos of pika foraging behavior. Preliminary results suggest that pikas may be changing important aspects of when and how they forage, including collecting food at night when temperatures are cooler. We are on track to complete our research within the timelines outlined in our permit proposal, and are excited to collaborate with both professional ecologists and local citizens in our progress.

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Understanding changing climate conditions in alpine habitats: a test of wildlife responses, limits and plasticity

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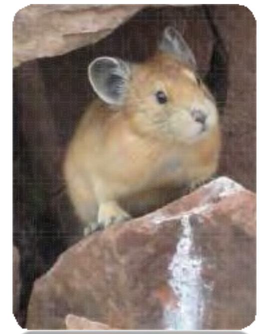

INTRODUCTION

Rapid climate change is one of the defining conservation issues of the 21st century[1]. The effects of changing conditions are seen in most biomes on earth and influence all levels of ecological hierarchy[2,3]. In Wyoming, climate change is one of five wildlife conservation challenges identified in the State Wildlife Action Plan (SWAP). With continued warming projected for at least the remainder of the 21st century, species in Wyoming and across the globe will be exposed to conditions that are different from those that shaped their evolutionary histories.

Phenotypic plasticity, the ability of an organism to respond to its environment with a change in form, behavior or movement, may provide species with a mechanism to keep pace with changing conditions. In fact, phenotypic plasticity often can accommodate rapid change better than adaptive evolutionary responses[4]. Behavioral plasticity (a type of phenotypic plasticity) is common across animal taxa. Moose (*Alces alces shirasi*), for example, seek shelter in conifer forests and riparian areas during the hottest part of summer days to avoid heat stress. Similarly, many songbird species nesting in sagebrush flats stand on the edges of their nests with their wings open to protect their offspring from inclement weather.

Despite increased research on the rate at which species can adjust to climate change, the degree to which behavioral plasticity allows species to buffer climate variability remains unclear. Even less well understood are the fitness (survival and reproduction) implications of flexible behavioral strategies in rapidly changing environments. For example, a moose cannot shelter under conifer trees indefinitely. At some point it must forage, drink water and find mates. Otherwise it will not survive or produce young. Behavioral plasticity can produce viable wildlife populations only if it helps individuals to maintain fitness and forestall population declines[5].

Wildlife managers, alone, cannot ameliorate climate change. The effects of climate change on even a single species are complicated, and difficult to plan for. Consequently, it is tempting to discount the potential risks because it seems that there is little that can be done. However, research that addresses species' responses to novel climate conditions will help to clarify population-level risks and effective management options. It will also help us to better understand characteristics that define species' vulnerability and resilience to climate change.

We examine how well temperature-sensitive animals can buffer warming temperatures through changes in behavior, using the American pika (*Ochotona princeps*) as a model species. Pikas are an ideal study species because they exhibit extreme sensitivity to ambient temperature and are one of the few vertebrates active year round in the alpine[6], where some of the most extreme climate changes are occurring[7,8]. Pikas also compile food caches (haypiles), during the summer which have been closely linked to over-winter survival[9]. If pikas can successfully modify behaviors that influence survival (such as foraging), it is possible that other species with similar life history characteristics may be capable of comparable flexibility.

RESEARCH METHODS

We conducted our work at 9 sites on the Bridger-Teton National Forest (BTNF) from July 1 – September 18. At each site we quantified both the degree to which pikas altered foraging strategies to moderate temperature stress, and the associated performance consequences of different strategies (measured by volume and quality of food caches). At each randomly selected pika territory, we deployed infrared-enabled video cameras to record foraging patterns over a 24-hour period (Fig. 1). Each camera was arrayed with three paired surface/subsurface temperature loggers to examine the relationship between temperature and food-caching behavior (Fig. 2). We measured the amount and diversity of surrounding vegetation using a modified line-point intercept approach[10] (Fig. 3), and assessed the quality (% moisture, % nitrogen, and fiber content) of cached vegetation by collecting live samples of plants in each individual's haypile (Fig. 4). To assess support for alternative mechanisms that may influence foraging behavior independent of temperature, we recorded a series of habitat characteristics, including proximity of nearest forage and distance to talus margin.

PROGRESS ON PROJECT OBJECTIVES

We made substantial progress on each project objective during the permit period, and are well-positioned to complete our work by the deadlines included in our study proposal.

Project objectives

Objective 1. Quantify the degree to which pikas alter foraging strategies to moderate temperature stress.

- Field data collection. From July 1 – September 18, 2015 we sampled 47 individuals (non-invasively), deployed 230 temperature sensors and recorded 7,000 videos of pika foraging behaviors. We also retrieved 54 sensors that were deployed during the 2014 field season. Together these 54 sensors recorded over 110,000 data points. Due to low capture success during the preceding two years of our work (see 2013 and 2014 Annual Reports, permit # JAC223103), we did not attempt to capture animals in 2015.
- Analysis. During the fall, we uploaded our video, image and temperature data files, and entered the data that we collected into an Access database. We also began analyzing the

videos that we recorded. In order to test our hypotheses each video must be watched, coded for specific behaviors and entered into a specialized software program.

Objective 2. Determine whether individuals that show greater flexibility in behavior also have higher fitness.

- Field data collection. In addition to the progress outlined in Objective 1, we also collected 108 plant samples and measured 126 haypiles. We will use information on haypile size and nutritional quality to assess whether individuals that shift foraging behaviors in response to temperature variability also maintain higher quality food caches.
- Laboratory data collection. Once we returned from the field, we dried and submitted each plant sample to the Soil, Water and Plant Testing Lab at Colorado State University for nutritional analyses.

Objective 3. Share results with agency collaborators and support efforts to include behavioral flexibility in ongoing conservation planning efforts, such as revisions to the SWAP.

- Engagement in conservation planning. We co-authored revisions to the American Pika, and the Montane, Subalpine, and Alpine Non-Forested Vegetation Habitat accounts in the 2015 SWAP revision (due out later this year). Both accounts referenced project-related advances in understanding wildlife and habitat responses to climate change. We also had in-person discussions about our work with Wyoming Game and Fish Department (WGFD) non-game biologists and BTNF staff responsible for wildlife and habitat management in the Greater Yellowstone Ecosystem. Finally, we are fostering new collaborations with WGFD biologists to enhance approaches for quantifying wildlife responses, and corresponding management options, under different scenarios of future climate.

- Collaboration on BTNF monitoring initiatives. In mid-summer we met with lead wildlife technicians from the Grey's River/Kemmerer and Jackson/Blackrock Districts to review and update the BTNF pika-monitoring plan that was initiated in 2011. We clarified survey protocols and developed a strategy for coordinated data sharing. During spring 2016, we will complete initial analyses to examine forest-wide trends in pika occupancy.
- Sharing results with collaborators. We presented papers at two professional conferences in 2015, including the annual meeting of the Wyoming Chapter of The Wildlife Society (WY TWS). The WY TWS meeting was well attended by agency staff, wildlife managers and conservation planners. In late-February 2016 I will also give an invited presentation on our work at the WGFD headquarters in Cheyenne.

CONCLUSIONS AND PROJECT EFFECTIVENESS

Preliminary results suggest that pikas may be changing important aspects of when and how they forage, including collecting food at night when temperatures are cooler. This is especially interesting because ecologists have long thought that pikas were active primarily during the day. As we continue with our work, we will determine the extent to which our preliminary results are consistent across individuals, and whether pikas that show greater flexibility in behavior also maintain higher quality caches. If pikas can adjust behaviors that affect survival (such as foraging), then it may signal hope for other high-elevation species faced with increasing temperatures.

While management plans and peer-reviewed publications are the currency of scientific discourse, additional outreach fosters much-needed public engagement in the scientific process. We continued adult-education activities associated with our project in 2015. This included bringing five volunteers into the field with our research team, as well as sharing our findings with an outdoors group based in Albany County, Wyoming. Finally, we were fortunate to publicize our work through media coverage with several organizations. Outlets included WyoFile, e-science News, UWYO Magazine (Vol. 17), University of Wyoming News and Sheridan Media.

We are delighted with our project progress to date, and look forward to completing our work by December, 2016.

ACKNOWLEDGMENTS

The US Geological Survey (USGS), University of Wyoming (UW), UW – Office of Research, Wyoming Game and Fish Department (WGFD), Natural Resource Conservation Service, Program in Ecology Summer Stipend Award, Haub School of Environment and Natural Resources Student Research and Creative Activities Grant, Reed W. Fautin Memorial Scholarship, L. Floyd Clark Graduate Scholarship and an anonymous donor funded this research, in addition to contributions by the Meg and Bert Raynes Wildlife Fund. Kerry Murphy (BTNF), DeeDee Witsen (BTNF), Dale Deiter (BTNF), Carol Havlick (WGFD), Mark Nelson (WGFD) and Colette Kuhfuss (UW) facilitated our research permits. Anna Chalfoun (USGS/UW) provided essential advice during all stages of project development and execution. Kerry Murphy, Susan Patla (WGFD), Merav Ben-David (UW), Tim Robinson (UW), Erik Beever (USGS) and Shannon Albeke (UW) gave feedback on study design and data management. Susan Colligan (BTNF) and Don DeLong (BTNF) were critical to securing field housing. Linda Merigliano (BTNF), Jason Wilmot (BTNF) and Jessica Shaw (BTNF) coordinated our bear safety and leave-no-trace training. Data collection during the 2015 field season would not have been possible without the dedication of: Melia DeVivo, Sarah DuBose, Carlin Girard, Morgan Graham, Marnye Hall, John Henningsen, Rhiannon Jakopak, Diana (Sweet) Miller, Matt Miller, Carolin Tappe and Ben Wise.

LITERATURE CITED

1. Hayes, D. Facing the inevitable. Agency efforts to collaborate on climate change. *Wildl. Prof.* **5,** 24–25 (2011).

2. Walther, G.-R. *et al.* Ecological responses to recent climate change. *Nature* **416,** 389–396 (2002).

3. Parmesan, C. Ecological and Evolutionary Responses to Recent Climate Change. *Annu. Rev. Ecol. Evol. Syst.* **37,** 637–669 (2006).

4. Austin, J. D., Miller, C. W. & Fletcher, R. J. in *Wildl. Conserv. a Chang. Clim.* (Brodie, J. F., Post, E. & Doak, D. F.) 38–57 (The University of Chicago Press, 2013).

5. Van Buskirk, J. in *Behav. Responses to a Chang. World* (Candolin, U. & Wong, B.) 145–158 (Oxford University Press, 2012).

6. Smith, A. & Weston, M. Ochotona princeps. *Mamm. Species* 1–8 (1990).

7. Pederson, G. T. *et al.* The unusual nature of recent snowpack declines in the North American cordillera. *Science* **333,** 332–5 (2011).

8. Shuman, B. Recent Wyoming temperature trends, their drivers, and impacts in a 14 ,000-year context. *Clim. Change* 429–447 (2012). doi:10.1007/s10584-011-0223-5

9. Dearing, D. The function of haypiles of pikas (Ochotona princeps). *J. Mamm* **78,** 1156–1163 (1997).

10. Levy, E. B. & Madden, E. . The point method for pasture analysis. *J. Agric.* **46,** 267–279 (1933).

FIGURES

Figure 1. Example camera deployment used to record pika foraging behavior on the Bridger-Teton National Forest. Red ovals highlight the camera placement. The red arrow indicates the location of the haypile.

Figure 2. Eighteen temperature sensors prepared for field deployment. Sensors were programmed, placed in a water-tight casing, and sealed into a wire-mesh cage (not pictured).

Figure 3. Daubenmire frame placed parallel to an 8 m transect near the talus margin. Vegetation surveys allowed us to quantify the amount, diversity and nutritional quality of plants available to individual pikas.

Figure 4. Example plant sample used to evaluate the nutritional quality of cached vegetation in a pika's haypile. Live samples of individual plants were collected in proportion to their occurrence in the haypile.

CLARIFYING EXPOSURE RISK OF SMALL MAMMALS TO ENERGY DEVELOPMENT IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Pocket mice

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: 1 July 2014 – 30 June 2017

PERIOD COVERED: 1 May 2015 – 31 August 2015

PREPARED BY: Kristina Harkins, University of Wyoming Zoology and Physiology Program

SUMMARY

Summer 2015 was the first field season of the statewide survey for pocket mice (*Perognathus* spp.). Long-term project goals include creating a protocol for rare and difficult to detect prairie species, occupancy and habitat analysis for pocket mice, and stable isotope analysis on diet partitioning between diet generalists (such as deermice; *Peromyscus maniculatus*) and diet specialists (such as pocket mice). The data presented in this report are preliminary and have not been statistically analyzed.

Sites were selected on public land in Wyoming that was <2,400 m in elevation and had <30% canopy cover. Original sites were randomly selected using the GRTS function in R and stratified by the 3 basin ecoregions in Wyoming. Once initial sites were established, additional paired sites were made in ArcGIS so that 2 sites could be surveyed simultaneously. Forty-seven sites were surveyed the first summer (Figure 1). Trapping grids were set up on the sites in a 4x20 trapping station grid with 25 m spacing between grid points. Two traps, 1 Sherman and 1 Havahart, were placed at each grid point to maximize captures. Additionally, 3 bait types (peanut butter and oat mix, 3-way horse feed with molasses, and sterilized bird seed) were used, with bait type alternating at each grid point. Sites were trapped for 4 consecutive nights with animals processed in the morning. Individuals were marked with ear tags unless the ear was too small, in which case the individual was PIT tagged. Measurements were taken to identify species for all pocket mice species and sagebrush voles (*Lemmiscus curtatus*).

Trapping was a huge success, with a total of 7,485 captures of 4,180 individuals (Table 1). Nineteen species were trapped across all sites, with species richness at the sites averaging 5.36 and ranging from 2 to 9 species per site (Figure 2). In addition to the small mammal species trapped, we also trapped 12 birds (mostly Lark Buntings [*Calamospiza melanocorys*] with 1 Lark Sparrow [*Chondestes grammacus*], 1 Western Meadowlark [*Sturnella neglecta*], and 1

Grasshopper Sparrow [*Ammodramus savannarum*]), 2 pale milksnakes [*Lampropeltis triangulum*], 2 spadefoot toads [*Spea* spp.], and 1 northern sagebrush lizard [*Sceloporus graciosus*]). We trapped 4 out of the 5 pocket mouse species in the state (Figure 3), with silky pocket mice (*P. flavus*) being the only target species not trapped. The olive-backed pocket mouse (*P. fasciatus*) was our 5th most frequently trapped species, with 130 individuals. Olive-backed pocket mice and sagebrush voles were trapped at 23 of 47 sites (49%). The 3 other pocket mice species were only trapped at ≤3 sites each.

Bait type and trap type varied among species, with results similar to what was expected. Havaharts outcompeted Shermans, with 66% of the captures occurring in Havaharts and only 34% occurring in Shermans (Table 2). Early in the summer, Longworth traps were used but not with enough frequency to be included in analysis (<1% of total captures). All species were trapped in Havaharts more frequently or were captured in both traps equally. The only species that was trapped in Shermans more frequently was bushy-tailed woodrat (*Neotoma cinerea*). Bait type was equal when all species were combined, but most species were captured more with 1 particular bait type (Table 3). Pocket mice, Ord's kangaroo rats (*Dipodomys ordii*), thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*), and plains harvest mice (*Reithrodontomys montanus*) were captured more with bird seed. Deermice, western harvest mice (*R. megalotis*), northern grasshopper mice (*Onychomys leucogaster*), and least chipmunks (*Tamias minimus*) were captured more with peanut butter. Only sagebrush voles and unknown *Microtus* spp. voles were captured more with the horse feed.

Vegetation data from the 2015 field season will be compiled and preliminary analysis will be done by May 2016. A 2nd field season for the summer of 2016 is planned, with 48 new sites scheduled for trapping. Three of next field season's sites are located where other researchers have trapped pocket mice in the past, and 2 new sites are located on National Wildlife Refuges in the Laramie Basin. Those 5 sites will not be considered in occupancy analysis since they are not randomly selected. Longworth traps will be added to 1 trapping line for each site. Field work will be completed by September 2016, and analysis will be completed the following fall.

Table 1. Individuals (new captures), recaptures, escapees, and the total number of captures for each small mammal species captured on our study site in Wyoming in 2015. Deermice (*Peromyscus maniculatus*) made up 72.4% of the total captures, Ord's kangaroo rats (*Dipodomys ordii*) were 11.7% of the captures, and all other species combined were 15.9% of the captures.

Common name	Species	Individuals	Recaptures	Escapees	Grand Total
Hispid pocket mouse	*Chaetodipus hispidus*	5	1	0	6
Ord's kangaroo rat	*Dipodomys ordii*	517	361	1	879
Sagebrush vole	*Lemmiscus curtatus*	171	15	3	189
Long-tailed vole	*Microtus longicaudus*	7	0	0	7
Montane vole	*Microtus montanus*	1	0	0	1
Prairie vole	*Microtus ochrogaster*	91	8	0	99
Unknown vole	*Microtus* species	12	5	0	17
Bushy-tailed woodrat	*Neotoma cinerea*	9	1	0	10
Northern grasshopper mouse	*Onychomys leucogaster*	28	7	0	35
Olive-backed pocket mouse	*Perognathus fasciatus*	130	57	0	187
Plains pocket mouse	*Perognathus flavescens*	5	3	0	8
Deer mouse	*Peromyscus maniculatus*	2775	2640	4	5419
Great Basin pocket mouse	*Perognathus parvus*	9	4	0	13
Western harvest mouse	*Reithrodontomys megalotis*	159	120	0	279
Plains harvest mouse	*Reithrodontomys montanus*	101	38	1	140
Thirteen-lined ground squirrel	*Ictidomys tridecemlineatus*	43	14	0	57
Unknown cottontail	*Sylvilagus* species	2	0	0	2
Least chipmunk	*Tamias minimus*	110	20	1	131
Escaped individuals	*unknown*	4	0	1	5
Shrew species	*Sorex* species	1	0	0	1
Grand total		4180	3294	11	7485

Table 2. The type of live trap in which each small mammal species was capture on our study site in Wyoming in 2015. Havaharts represented 66% of overall captures, and Shermans 34%. Longworth traps were not used extensively enough to be evaluated this year and will be used more in the summer of 2016. Only 1 species (bushy-tailed woodrat [*Neotoma cinerea*]) was trapped in Shermans more frequently than Havaharts.

Common name	Havahart	Longworth	Sherman	Unknown	Total
Hispid pocket mouse	3	0	3	0	6
Ord's kangaroo rat	491	0	388	0	879
Sagebrush vole	134	0	51	3	188
Long-tailed vole	5	0	2	0	7
Montane vole	1	0	0	0	1
Prairie vole	77	0	22	0	99
Unknown vole	14	0	3	0	17
Bushy-tailed woodrat	1	0	9	0	10
Northern grasshopper mouse	17	0	18	0	35
Olive-backed pocket mouse	147	0	40	0	187
Plains pocket mouse	5	0	3	0	8
Deer mouse	3616	11	1782	9	5418
Great Basin pocket mouse	10	0	3	0	13
Western harvest mouse	192	1	86	0	279
Plains harvest mouse	102	4	31	2	139
Thirteen-lined ground squirrel	34	0	23	0	57
Unknown cottontail	1	0	1	0	2
Least chipmunk	84	0	47	0	131
Escapee	4	0	1	0	5
Unknown shrew	0	0	1	0	1
Grand total	4938	16	2514	14	7482

Table 3. This table shows the captures for each bait type by species. When all species were combined, there was very little difference in captures between bait types. Capture rates for different bait types varied at an individual species level. Voles (*Microtus* spp.) were captured more with 3-way horse feed. Northern grasshopper mice (*Onychomys leucogaster*), deermice (*Peromyscus maniculatus*), western harvest mice (*Reithrodontomys megalotis*), and least chipmunks (*Tamias minimum*) were captured more with peanut butter. Kangaroo rats (*Dipodomys ordii*), olive-backed pocket mice (*Perognathus fasciatus*), Great Basin pocket mice (*P. parvus*), plains harvest mice (*Reithrodontomys montanus*), and thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*) were captured more with bird seed. The only species with >10 captures that did not show a difference in capture rate for bait was the prairie vole (*M. ochrogaster*).

Common name	Horse feed	Peanut butter	Bird seed	Unknown	Total
Hispid pocket mouse	2	0	3	1	6
Ord’s kangaroo rat	241	282	356	0	879
Sagebrush vole	74	47	65	3	189
Long-tailed vole	2	3	2	0	7
Montane vole		0	1	0	1
Prairie vole	38	22	39	0	99
Unknown vole	13	3	1	0	17
Bushy-tailed woodrat	4	2	4	0	10
Northern grasshopper mouse	5	21	8	1	35
Olive-backed pocket mouse	38	28	121	0	187
Plains pocket mouse	1	0	7	0	8
Deer mouse	1630	2071	1698	20	5419
Great Basin pocket mouse		3	10	0	13
Western harvest mouse	95	105	77	2	279
Plains harvest mouse	46	35	59	0	140
Thirteen-lined ground squirrel	7	17	33	0	57
Unknown cottontail	1	1	0	0	2
Least chipmunk	16	68	45	2	131
Escapee	4	0	1	0	5
Unknown shrew	1	0	0	0	1
Grand total	2218	2708	2530	29	7485

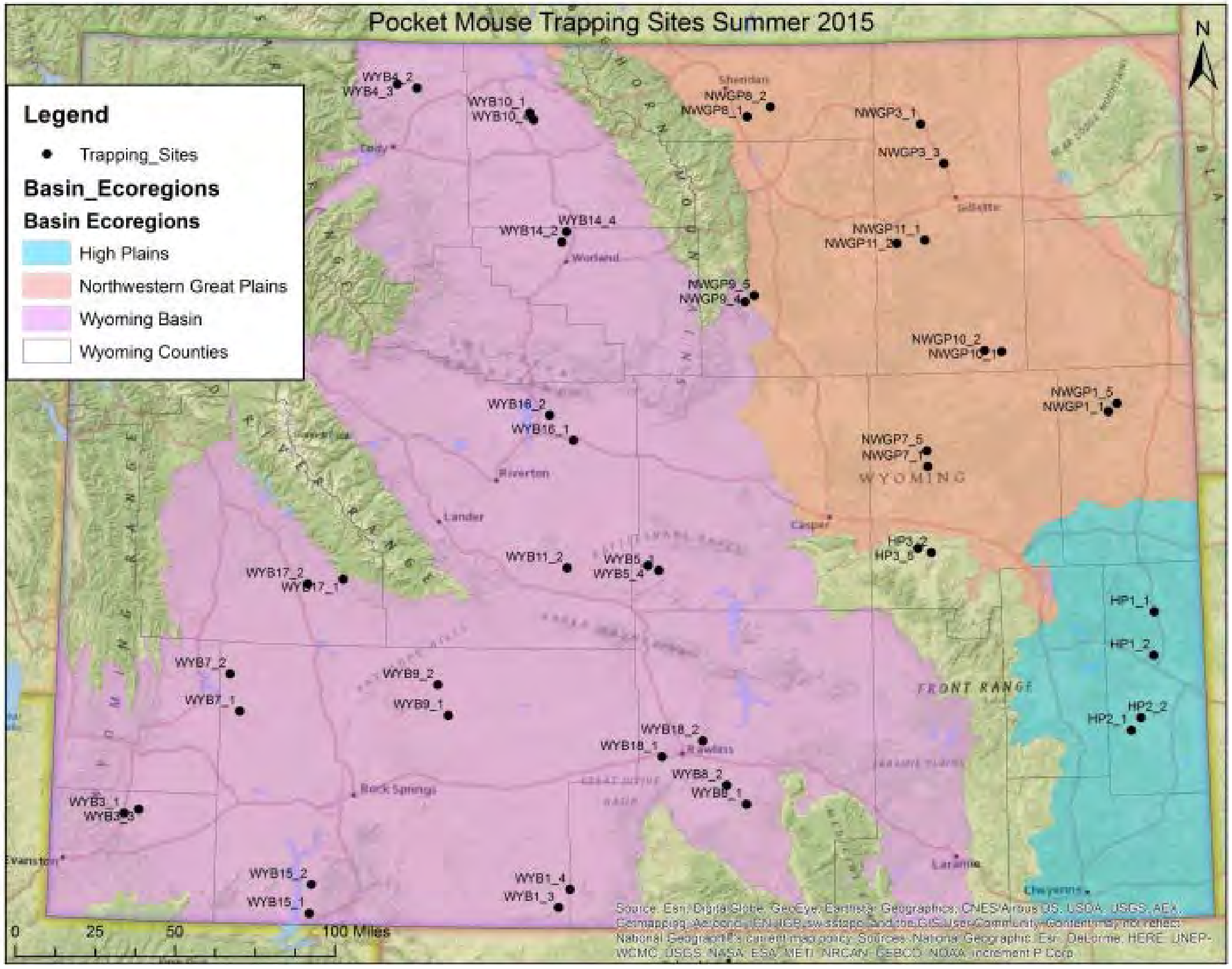

Figure 1. The 47 sites we surveyed for small mammals in Wyoming. Surveys took place from the 26 May – 22 August 2015. Sites were stratified by ecoregion, and the number surveyed in each ecoregion depended on the square mileage of the study area in that ecoregion. Site distribution was: 27 sites in the Wyoming Basin, 14 sites in the Northwestern Great Plains, and 6 sites in the High Plains.

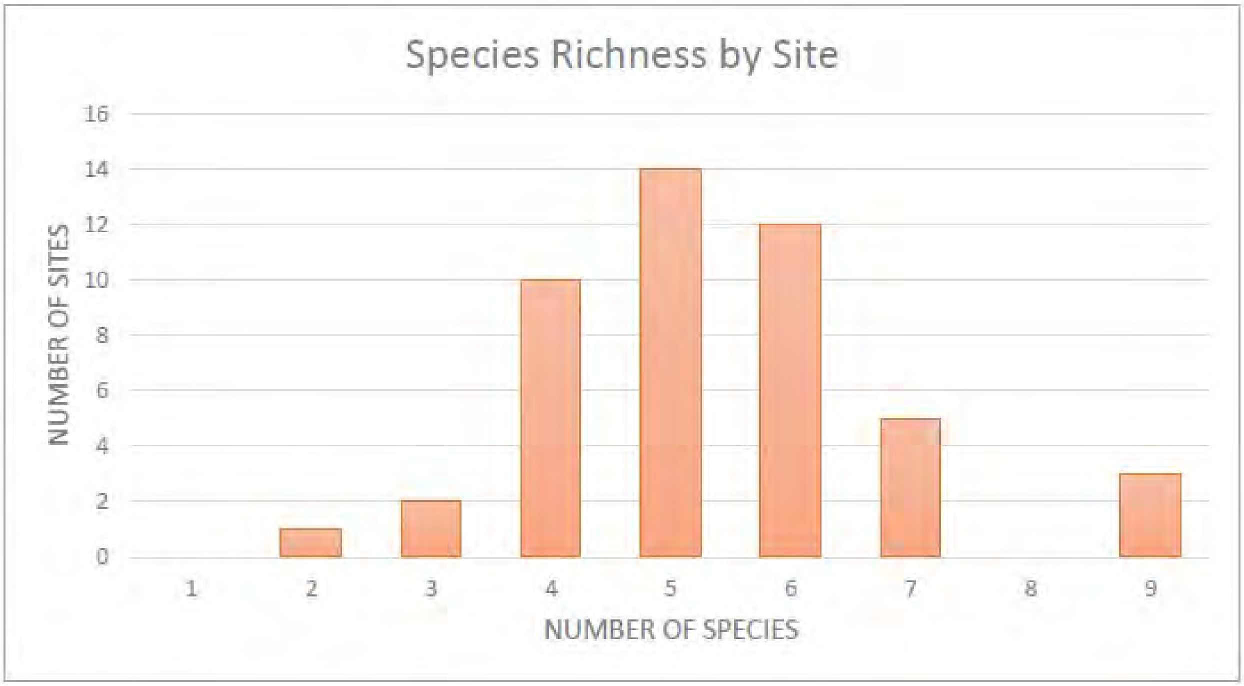

Figure 2. Species richness on our study site in Wyoming in summer 2015. The x-axis is the number of species trapped at a site, and the y-axis is the number of sites with that many species trapped per site. The average number of species trapped at a site was 5.36, with 3 sites having low species richness (2-3 species) and 8 sites having high species richness (7-9 species).

Figure 3. The 4 pocket mouse species trapped on our study site in Wyoming in 2014. Top left: Great Basin pocket mouse (*Perognathus parvus*). Top right: Hispid pocket mouse (*Chaetodipus hispidus*). Bottom left: Olive-backed pocket mouse (*P. fasciatus*). Bottom right: Plains pocket mouse (*P. flavescens*).

BEHAVIORAL, DEMOGRAPHIC, AND COMMUNITY RESPONSES OF SMALL MAMMALS TO HABITAT HOMOGENIZATION BY CHEATGRASS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Small mammals

FUNDING SOURCE: Unites States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: 1 July 2012 – 30 June 2015

PERIOD COVERED: 1 July 2012 – 30 June 2015

PREPARED BY: Joseph Ceradini, Wyoming Cooperative Fish and Wildlife Research Unit
Dr. Anna Chalfoun, Wyoming Cooperative Fish and Wildlife Research Unit

SUMMARY

Invasive plants can alter the structure and composition of native plant communities, which can affect ecosystem processes and habitat quality for a wide variety of organisms. Habitat alteration due to invasive plants often has negative consequences for native species; however, the strength, directionality, and shape of effects strongly depend on the interaction between the type of habitat change and native species' traits, such as natural history characteristics. Therefore, to prioritize conservation of vulnerable species, it is critical to effectively predict native species' responses to invasive plants, which may be facilitated by a framework based on species' traits. We studied changes in small mammal populations and communities, and in habitat heterogeneity, across a gradient of cheatgrass (*Bromus tectorum*) cover in a mixed-grass prairie in northeast Wyoming, USA. In addition, we assessed the ability of native species' traits, such as habitat association, to predict small mammal responses to cheatgrass invasion.

Research was conducted in Thunder Basin National Grassland, Wyoming from May to August 2013 and 2014. In 2014, we continued to address our research questions on the same 14 sites used in 2013. We added 2 additional sites in 2014, for a total of 16 sites spanning a gradient of cheatgrass cover (mean cover = 20%, range = 0, 74). All 16 sites were live-trapped using mark-recapture for 2 sessions with approximately 1 month between trap sessions. Each trap session contained 4 consecutive trap nights, for a total of 8 trap nights per site, per year. This trap schedule enabled us to estimate occupancy, abundance, and survival of small mammal populations in relation to cheatgrass cover.

To control for potential confounding factors, such as weather, sites were separated into blocks of 2 native-invasive pairs (4 sites). Sites within a block were trapped simultaneously for

4 consecutive nights. Each trapping site contained 120 live traps separated by 15 m, making a 2.2-ha grid. To target a broader suite of small mammal species, each grid was 2/3 Shermans (80 traps) and 1/3 Havaharts (40 traps). In 2013, 8 out of 12 sites had a pitfall array with drift fences; however, no mammals were captured in pitfalls, so pitfalls were not implemented in 2014.

Our habitat heterogeneity index decreased with cheatgrass cover. Species richness did not vary with cheatgrass; however, pocket mouse (*Perognathus* spp.) and harvest mouse (*Reithrodontomys* spp.) occupancy tended to decrease and increase, respectively, with cheatgrass cover, suggesting a shift in community composition. Cheatgrass had little effect on occupancy for the remaining species, and deermouse (*Peromyscus maniculatus*) abundance increased marginally with cheatgrass. Species' responses to cheatgrass primarily corresponded with our *a priori* predictions based on species' traits. In our species' traits analysis, the probability of occupancy varied significantly with a species' habitat association but not with diet or mode of locomotion. When considered within the context of a particular habitat change by an invasive plant, relevant species' traits may provide a useful framework for predicting species' responses to invasive plants.

A critical next step in understanding this invasive plant-wildlife relationship was to assess why habitat changes by cheatgrass altered small mammal populations and communities, and to quantify changes in fitness, which more reliably indicate habitat quality. In 2014, we implemented a new experiment in order to better understand the mechanisms behind the patterns we observed in 2013 and 2014. Based on our 2013 data, we hypothesized that the presence of cheatgrass may alter perceived or actual predation risk for small mammals. We used a foraging experiment based on giving-up density to assess how cheatgrass altered perceived risk. The giving-up density is the quantity of seeds at which the animal ceases to forage. We conducted foraging trials on 4 cheatgrass and 4 native sites. Each site had 7 pairs of foraging trays that were set with seed for 3 consecutive nights, twice per summer (stratified by moon quarter). In addition, in 2013 and 2014, we assessed deermouse microhabitat selection in relation to cheatgrass by powder tracking individuals. We analyzed 38 tracks from unique individuals that were tracked on sites spanning a gradient of cheatgrass cover. Habitat selection may also reflect perceived risk; thus, we assessed deermouse microhabitat selection in response to cheatgrass, shrub cover, and moonlight at two spatial scales. Finally, we used mark-recapture to quantify deer mouse apparent survival across a cheatgrass gradient.

In our foraging experiment, shrubs were more important as protective cover in cheatgrass dominated habitats, suggesting that cheatgrass increased predation risk. Additionally, deermice significantly avoided cheatgrass and selected shrub cover at two spatial scales; however, selection for cheatgrass and shrubs did not interact. Deermouse apparent survival varied with a cheatgrass-shrub interaction, corresponding with our foraging experiment results, and providing a rare example of a native plant likely mediating the effects of an invasive plant on wildlife. When results from all 3 metrics – foraging behavior, habitat selection, and apparent survival – are considered, it is likely that the increased perceived risk in cheatgrass habitats reflected actual risk with negative fitness consequences for small mammals. Our research is timely given the global scope of current and potential future impacts of invasive plants, particularly annual grasses. By linking changes in small mammal perceived risk and fitness due to cheatgrass invasion, we provide a critical next step to gaining a mechanistic understanding of the effects of habitat alteration due to non-native plant invasion.

APPENDIX I
THE OFFICIAL STATE LIST OF THE COMMON AND SCIENTIFIC NAMES OF THE BIRDS, MAMMALS, AMPHIBIANS, AND REPTILES IN WYOMING

THE OFFICIAL STATE LIST OF THE COMMON AND SCIENTIFIC NAMES OF THE BIRDS, MAMMALS, AMPHIBIANS, AND REPTILES IN WYOMING

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
		BIRDS [c, d]		
Waterfowl **Order: Anseriformes** **Family: Anatidae**				
171.0	Greater White-fronted Goose *	*Anser albifrons*	(FL)	M
169.0	Snow Goose *	*Chen caerulescens*		M
170.0	Ross's Goose *	*Chen rossii*	(FL)	M
174.0	Brant	*Branta bernicla*	(AS)	A, Includes Black Brant (174.0)
172.2	Cackling Goose	*Branta hutchinsii*	(FL)	A
172.0	Canada Goose *	*Branta canadensis*		R
181.0	Trumpeter Swan *	*Cygnus buccinator*	(FL)	R, NSS2/II, No season
180.0	Tundra Swan *	*Cygnus columbianus*		W, No season
179.0	Whooper Swan	*Cygnus cygnus*	(AS)	A
144.0	Wood Duck *	*Aix sponsa*		S
135.0	Gadwall *	*Anas strepera*		R
136.0	Eurasian Wigeon	*Anas penelope*	(AS)	A
137.0	American Wigeon *	*Anas americana*		R
133.0	American Black Duck	*Anas rubripes*	(AS)	A
132.0	Mallard *	*Anas platyrhynchos*		R
134.0	Mottled Duck	*Anas fulvigula*	(AS)	A
140.0	Blue-winged Teal *	*Anas discors*		S
141.0	Cinnamon Teal *	*Anas cyanoptera*		S
142.0	Northern Shoveler *	*Anas clypeata*		S
143.0	Northern Pintail *	*Anas acuta*		R
139.2	Garganey	*Anas querquedula*	(AS)	A
139.0	Green-winged Teal *	*Anas crecca*		R
147.0	Canvasback *	*Aythya valisineria*		S
146.0	Redhead *	*Aythya americana*		S
150.0	Ring-necked Duck *	*Aythya collaris*		S
149.1	Tufted Duck	*Aythya fuligula*	(AS)	A
148.0	Greater Scaup *	*Aythya marila*	(FL)	M
149.0	Lesser Scaup *	*Aythya affinis*		S
155.0	Harlequin Duck *	*Histrionicus histrionicus*		S, NSS3/II
166.0	Surf Scoter *	*Melanitta perspicillata*	(FL)	M
165.0	White-winged Scoter *	*Melanitta fusca*	(FL)	M
163.0	Black Scoter	*Melanitta americana*	(AS)	A
154.0	Long-tailed Duck *	*Clangula hyemalis*	(FL)	M
153.0	Bufflehead *	*Bucephala albeola*		R
151.0	Common Goldeneye *	*Bucephala clangula*		R
152.0	Barrow's Goldeneye *	*Bucephala islandica*		R
131.0	Hooded Merganser *	*Lophodytes cucullatus*		R
129.0	Common Merganser *	*Mergus merganser*		R
130.0	Red-breasted Merganser *	*Mergus serrator*		S
167.0	Ruddy Duck *	*Oxyura jamaicensis*		S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
<u>Gallinaceous Birds</u> **Order: Galliformes**				
Family: Odontophoridae				
289.0	Northern Bobwhite *	*Colinus virginianus*	(AS)	R
Family: Phasianidae				
288.2	Chukar *	*Alectoris chukar*		R
288.1	Gray Partridge *	*Perdix perdix*		R
309.1	Ring-necked Pheasant *	*Phasianus colchicus*		R
300.0	Ruffed Grouse *	*Bonasa umbellus*		R
309.0	Greater Sage-Grouse *	*Centrocercus urophasianus*		R, NSS2/I
304.0	White-tailed Ptarmigan *	*Lagopus leucura*	(AS)	R, No season
297.0	Dusky Grouse *	*Dendragapus obscurus*		R
308.0	Sharp-tailed Grouse *	*Tympanuchus phasianellus*		R, NSS4/II, Includes Columbian subspecies
305.0	Greater Prairie-Chicken	*Tympanuchus cupido*	(AS)	A
310.0	Wild Turkey *	*Meleagris gallopavo*		R
<u>Loons</u> **Order: Gaviiformes** **Family: Gaviidae**				
011.0	Red-throated Loon	*Gavia stellata*	(AS)	M
010.0	Pacific Loon	*Gavia pacifica*	(FL)	M
007.0	Common Loon	*Gavia immer*		S, NSS1/I
008.0	Yellow-billed Loon	*Gavia adamsii*	(AS)	A
<u>Grebes</u> **Order: Podicipediformes** **Family: Podicipedidae**				
006.0	Pied-billed Grebe	*Podilymbus podiceps*		S
003.0	Horned Grebe	*Podiceps auritus*		S
002.0	Red-necked Grebe	*Podiceps grisegena*	(AS)	S
004.0	Eared Grebe	*Podiceps nigricollis*		S
001.0	Western Grebe	*Aechmophorus occidentalis*		S
001.1	Clark's Grebe	*Aechmophorus clarkii*		S, NSSU/II
<u>Shearwaters</u> **Order: Procellariiformes** **Family: Procellariidae**				
088.1	Streaked Shearwater	*Calonectris leucomelas*	(AS)	A
<u>Storks</u> **Order: Ciconiiformes** **Family: Ciconiidae**				
188.0	Wood Stork	*Mycteria americana*	(AS)	A, Endangered
<u>Cormorants and Frigatebirds</u> **Order: Suliformes** **Family: Fregatidae**				
128.2	Lesser Frigatebird	*Fregata ariel*	(AS)	A
Family: Phalacrocoracidae				
120.0	Double-crested Cormorant	*Phalacrocorax auritus*		S
<u>Pelicans and Wading Birds</u> **Order: Pelecaniformes** **Family: Pelecanidae**				
125.0	American White Pelican	*Pelecanus erythrorhynchos*		S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
126.0	Brown Pelican	*Pelecanus occidentalis*	(AS)	A
Family: Ardeidae				
190.0	American Bittern	*Botaurus lentiginosus*	(FL)	S, NSS3/II
191.0	Least Bittern	*Ixobrychus exilis*	(AS)	A
194.0	Great Blue Heron	*Ardea herodias*		S
196.0	Great Egret	*Ardea alba*	(FL)	A
197.0	Snowy Egret	*Egretta thula*		S, NSS3/II
200.0	Little Blue Heron	*Egretta caerulea*	(AS)	A
199.0	Tricolored Heron	*Egretta tricolor*	(AS)	A
200.1	Cattle Egret	*Bubulcus ibis*	(FL)	S
201.0	Green Heron	*Butorides virescens*	(AS)	M
202.0	Black-crowned Night-Heron	*Nycticorax nycticorax*		S, NSS3/II
203.0	Yellow-crowned Night-Heron	*Nyctanassa violacea*	(AS)	A
Family: Threskiornithidae				
184.0	White Ibis	*Eudocimus albus*	(AS)	A
186.0	Glossy Ibis	*Plegadis falcinellus*	(AS)	A
187.0	White-faced Ibis	*Plegadis chihi*		S, NSS3/II
<u>Diurnal Birds of Prey</u> **Order: Accipitriformes**				
Family: Cathartidae				
326.0	Black Vulture	*Coragyps atratus*	(AS)	A
325.0	Turkey Vulture	*Cathartes aura*		S
Family: Pandionidae				
364.0	Osprey	*Pandion haliaetus*		S
Family: Accipitridae				
328.0	White-tailed Kite	*Elanus leucurus*	(AS)	A
329.0	Mississippi Kite	*Ictinia mississippiensis*	(AS)	A
352.0	Bald Eagle	*Haliaeetus leucocephalus*		R, NSS2/I
331.0	Northern Harrier	*Circus cyaneus*		S
332.0	Sharp-shinned Hawk	*Accipiter striatus*		S
333.0	Cooper's Hawk	*Accipiter cooperii*		S
334.0	Northern Goshawk	*Accipiter gentilis*		R, NSSU/I
335.0	Harris's Hawk	*Parabuteo unicinctus*	(AS)	A
339.0	Red-shouldered Hawk	*Buteo lineatus*	(AS)	A
343.0	Broad-winged Hawk	*Buteo platypterus*	(FL)	S
342.0	Swainson's Hawk	*Buteo swainsoni*		S, NSSU/II
337.0	Red-tailed Hawk	*Buteo jamaicensis*		R, Includes Harlan's Hawk (338.0)
347.0	Rough-legged Hawk	*Buteo lagopus*		W
348.0	Ferruginous Hawk	*Buteo regalis*		R, NSSU/I
349.0	Golden Eagle	*Aquila chrysaetos*		R
<u>Marshbirds</u> **Order: Gruiformes** **Family: Rallidae**				
215.0	Yellow Rail	*Coturnicops noveboracensis*	(AS)	A
216.0	Black Rail	*Laterallus jamaicensis*	(AS)	A
212.0	Virginia Rail *	*Rallus limicola*		S, NSS3/II
214.0	Sora *	*Porzana carolina*		S
218.0	Purple Gallinule	*Porphyrio martinicus*	(AS)	A
219.0	Common Gallinule	*Gallinula chloropus*	(AS)	A

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
221.0	American Coot *	*Fulica americana*		S
Family: Gruidae				
206.0	Sandhill Crane *	*Grus canadensis*		S, Includes Greater Sandhill Crane subspecies
204.0	Whooping Crane	*Grus americana*	(AS)	S, Endangered
<u>Shorebirds</u> **Order: Charadriiformes** **Family: Recurvirostridae**				
226.0	Black-necked Stilt	*Himantopus mexicanus*		S
225.0	American Avocet	*Recurvirostra americana*		S
Family: Charadriidae				
270.0	Black-bellied Plover	*Pluvialis squatarola*		M
272.0	American Golden-Plover	*Pluvialis dominica*	(FL)	M
278.0	Snowy Plover	*Charadrius nivosus*	(AS)	S
274.0	Semipalmated Plover	*Charadrius semipalmatus*		M
277.0	Piping Plover	*Charadrius melodus*	(AS)	M, Threatened
273.0	Killdeer	*Charadrius vociferus*		S
281.0	Mountain Plover	*Charadrius montanus*		S, NSSU/I
Family: Scolopacidae				
263.0	Spotted Sandpiper	*Actitis macularius*		S
256.0	Solitary Sandpiper	*Tringa solitaria*		M
254.0	Greater Yellowlegs	*Tringa melanoleuca*		M
258.0	Willet	*Tringa semipalmata*		S
255.0	Lesser Yellowlegs	*Tringa flavipes*		M
261.0	Upland Sandpiper	*Bartramia longicauda*	(FL)	S, NSSU/II
265.0	Whimbrel	*Numenius phaeopus*	(FL)	M
264.0	Long-billed Curlew	*Numenius americanus*		S, NSS3/II
251.0	Hudsonian Godwit	*Limosa haemastica*	(AS)	M
249.0	Marbled Godwit	*Limosa fedoa*		M
283.0	Ruddy Turnstone	*Arenaria interpres*	(FL)	M
234.0	Red Knot	*Calidris canutus*	(AS)	M
233.0	Stilt Sandpiper	*Calidris himantopus*		M
248.0	Sanderling	*Calidris alba*		M
243.0	Dunlin	*Calidris alpina*	(FL)	M
241.0	Baird's Sandpiper	*Calidris bairdii*		M
242.0	Least Sandpiper	*Calidris minutilla*		M
240.0	White-rumped Sandpiper	*Calidris fuscicollis*	(FL)	M
262.0	Buff-breasted Sandpiper	*Calidris subruficollis*	(AS)	M
239.0	Pectoral Sandpiper	*Calidris melanotos*		M
246.0	Semipalmated Sandpiper	*Calidris pusilla*		M
247.0	Western Sandpiper	*Calidris mauri*		M
231.0	Short-billed Dowitcher	*Limnodromus griseus*	(AS)	M
232.0	Long-billed Dowitcher	*Limnodromus scolopaceus*		M
230.0	Wilson's Snipe	*Gallinago delicata*		S
228.0	American Woodcock	*Scolopax minor*	(AS)	A
224.0	Wilson's Phalarope	*Phalaropus tricolor*		S
223.0	Red-necked Phalarope	*Phalaropus lobatus*		M
222.0	Red Phalarope	*Phalaropus fulicarius*	(AS)	A

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
<u>Seabirds, Gulls, and Terns</u> **Order: Charadriiformes** **Family: Stercorariidae**				
036.0	Pomarine Jaeger	*Stercorarius pomarinus*	(AS)	A
037.0	Parasitic Jaeger	*Stercorarius parasiticus*	(AS)	A
038.0	Long-tailed Jaeger	*Stercorarius longicaudus*	(AS)	A
Family: Alcidae				
023.0	Long-billed Murrelet	*Brachyramphus perdix*	(AS)	A
021.0	Ancient Murrelet	*Synthliboramphus antiquus*	(AS)	A
Family: Laridae				
040.0	Black-legged Kittiwake	*Rissa tridactyla*	(AS)	A
062.0	Sabine's Gull	*Xema sabini*	(FL)	M
060.0	Bonaparte's Gull	*Chroicocephalus philadelphia*		M
055.1	Black-headed Gull	*Chroicocephalus ridibundus*	(AS)	A
060.1	Little Gull	*Hydrocoloeus minutus*	(AS)	A
061.0	Ross's Gull	*Rhodostethia rosea*	(AS)	A
058.0	Laughing Gull	*Larus atricilla*	(AS)	A
059.0	Franklin's Gull	*Larus pipixcan*		S, NSS3/II
057.0	Heermann's Gull	*Larus heermanni*	(AS)	A
055.0	Mew Gull	*Larus canus*	(AS)	A
054.0	Ring-billed Gull	*Larus delawarensis*		S
053.0	California Gull	*Larus californicus*		S
051.0	Herring Gull	*Larus argentatus*		M
043.1	Thayer's Gull	*Larus thayeri*	(AS)	A
043.0	Iceland Gull	*Larus glaucoides*	(AS)	A
050.0	Lesser Black-backed Gull	*Larus fuscus*	(AS)	A
044.0	Glaucous-winged Gull	*Larus glaucescens*	(AS)	A
042.0	Glaucous Gull	*Larus hyperboreus*	(AS)	A
047.0	Great Black-backed Gull	*Larus marinus*	(AS)	A, (AS) except L19 & L27
074.0	Least Tern	*Sternula antillarum*	(AS)	A, Endangered
064.0	Caspian Tern	*Hydroprogne caspia*		S, NSS3/II
077.0	Black Tern	*Chlidonias niger*		S, NSS3/II
070.0	Common Tern	*Sterna hirundo*	(FL)	M
071.0	Arctic Tern	*Sterna paradisaea*	(AS)	A
069.0	Forster's Tern	*Sterna forsteri*		S, NSS3/II
<u>Doves and Pigeons</u> **Order: Columbiformes** **Family: Columbidae**				
313.1	Rock Pigeon	*Columba livia*		R
312.0	Band-tailed Pigeon	*Patagioenas fasciata*	(AS)	M
315.9	Eurasian Collared-Dove	*Streptopelia decaocto*		R
319.0	White-winged Dove	*Zenaida asiatica*	(FL)	A
316.0	Mourning Dove *	*Zenaida macroura*		S
315.0	Passenger Pigeon	*Ectopistes migratorius*		Extinct
<u>Cuckoos</u> **Order: Cuculiformes** **Family: Cuculidae**				
387.0	Yellow-billed Cuckoo	*Coccyzus americanus*	(FL)	S, NSSU/III
388.0	Black-billed Cuckoo	*Coccyzus erythropthalmus*	(FL)	S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
<u>Owls</u> **Order: Strigiformes** **Family: Tytonidae**				
365.0	Barn Owl	*Tyto alba*	(AS)	S,
Family: Strigidae				
374.0	Flammulated Owl	*Psiloscops flammeolus*	(AS)	S
373.2	Western Screech-Owl	*Megascops kennicottii*	(AS)	R
373.0	Eastern Screech-Owl	*Megascops asio*	(FL)	R
375.0	Great Horned Owl	*Bubo virginianus*		R
376.0	Snowy Owl	*Bubo scandiacus*	(AS)	W
377.0	Northern Hawk Owl	*Surnia ulula*	(AS)	A
379.0	Northern Pygmy-Owl	*Glaucidium gnoma*	(FL)	R, NSSU/II
378.0	Burrowing Owl	*Athene cunicularia*		S, NSSU/I
368.0	Barred Owl	*Strix varia*	(AS)	A
370.0	Great Gray Owl	*Strix nebulosa*		R, NSSU/I
366.0	Long-eared Owl	*Asio otus*		R
367.0	Short-eared Owl	*Asio flammeus*		R, NSS4/II
371.0	Boreal Owl	*Aegolius funereus*	(FL)	R, NSS3/II
372.0	Northern Saw-whet Owl	*Aegolius acadicus*	(FL)	R
<u>Goatsuckers</u> **Order: Caprimulgiformes** **Family: Caprimulgidae**				
421.0	Lesser Nighthawk	*Chordeiles acutipennis*	(AS)	A
420.0	Common Nighthawk	*Chordeiles minor*		S
418.0	Common Poorwill	*Phalaenoptilus nuttallii*		S
<u>Swifts</u> **Order: Apodiformes** **Family: Apodidae**				
422.0	Black Swift	<u>*Cypseloides niger*</u>	(AS)	M
423.0	Chimney Swift	*Chaetura pelagica*	(FL)	S
424.0	Vaux's Swift	*Chaetura vauxi*	(AS)	A
425.0	White-throated Swift	*Aeronautes saxatalis*		S
<u>Hummingbirds</u> **Order: Apodiformes** **Family: Trochilidae**				
426.0	Magnificent Hummingbird	*Eugenes fulgens*	(AS)	A
428.0	Ruby-throated Hummingbird	*Archilochus colubris*	(AS)	A
429.0	Black-chinned Hummingbird	*Archilochus alexandri*	(FL)	S
431.0	Anna's Hummingbird	*Calypte anna*	(AS)	A
432.0	Broad-tailed Hummingbird	*Selasphorus platycercus*		S
433.0	Rufous Hummingbird	*Selasphorus rufus*		S
436.0	Calliope Hummingbird	*Selasphorus calliope*		S
<u>Kingfishers</u> **Order: Coraciiformes** **Family: Alcedinidae**				
390.0	Belted Kingfisher	*Megaceryle alcyon*		R
<u>Woodpeckers</u> **Order: Piciformes** **Family: Picidae**				
408.0	Lewis's Woodpecker	*Melanerpes lewis*		S, NSSU/II

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information a, b
406.0	Red-headed Woodpecker	*Melanerpes erythrocephalus*	(FL)	S
407.0	Acorn Woodpecker	*Melanerpes formicivorus*	(AS)	A
409.0	Red-bellied Woodpecker	*Melanerpes carolinus*	(AS)	A
404.0	Williamson's Sapsucker	*Sphyrapicus thyroideus*		S
402.0	Yellow-bellied Sapsucker	*Sphyrapicus varius*	(AS)	A
402.1	Red-naped Sapsucker	*Sphyrapicus nuchalis*		S
394.0	Downy Woodpecker	*Picoides pubescens*		R
393.0	Hairy Woodpecker	*Picoides villosus*		R
399.0	White-headed Woodpecker	*Picoides albolarvatus*	(AS)	A
401.0	American Three-toed Woodpecker	*Picoides dorsalis*		R
400.0	Black-backed Woodpecker	*Picoides arcticus*	(FL)	R, NSSU/II
412.2	Northern Flicker	*Colaptes auratus*		R, Includes Red-shafted and Yellow-shafted
405.0	Pileated Woodpecker	*Dryocopus pileatus*	(AS)	A
Falcons **Order: Falconiformes** **Family: Falconidae**				
362.0	Crested Caracara	*Caracara cheriway*	(AS)	A
360.0	American Kestrel	*Falco sparverius*		S
357.0	Merlin	*Falco columbarius*		R, NSSU/III
354.0	Gyrfalcon	*Falco rusticolus*	(AS)	W
356.0	Peregrine Falcon	*Falco peregrinus*	(FL)	R, NSS3/II
355.0	Prairie Falcon	*Falco mexicanus*		R
Passerines **Order: Passeriformes** **Family: Tyrannidae**				
459.0	Olive-sided Flycatcher	*Contopus cooperi*		S
462.0	Western Wood-Pewee	*Contopus sordidulus*		S
461.0	Eastern Wood-Pewee	*Contopus virens*	(AS)	A
466.0	Willow Flycatcher	*Empidonax traillii*		S, NSS4/III
467.0	Least Flycatcher	*Empidonax minimus*	(FL)	S
468.0	Hammond's Flycatcher	*Empidonax hammondii*	(FL)	S
469.1	Gray Flycatcher	*Empidonax wrightii*	(FL)	S
469.0	Dusky Flycatcher	*Empidonax oberholseri*		S
464.0	Cordilleran Flycatcher	*Empidonax occidentalis*		S
456.0	Eastern Phoebe	*Sayornis phoebe*	(AS)	S
457.0	Say's Phoebe	*Sayornis saya*		S
471.0	Vermilion Flycatcher	*Pyrocephalus rubinus*	(AS)	A
454.0	Ash-throated Flycatcher	*Myiarchus cinerascens*	(FL)	S, NSS3/II
452.0	Great Crested Flycatcher	*Myiarchus crinitus*	(AS)	A
448.0	Cassin's Kingbird	*Tyrannus vociferans*	(FL)	S
447.0	Western Kingbird	*Tyrannus verticalis*		S
444.0	Eastern Kingbird	*Tyrannus tyrannus*		S
443.0	Scissor-tailed Flycatcher	*Tyrannus forficatus*	(AS)	A
Family: Laniidae				
622.0	Loggerhead Shrike	*Lanius ludovicianus*		S
621.0	Northern Shrike	*Lanius excubitor*		W
Family: Vireonidae				
631.0	White-eyed Vireo	*Vireo griseus*	(AS)	A
634.0	Gray Vireo	*Vireo vicinior*	(AS)	S

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628.0	Yellow-throated Vireo	*Vireo flavifrons*	(AS)	A
629.1	Plumbeous Vireo	*Vireo plumbeus*		S
629.2	Cassin's Vireo	*Vireo cassinii*	(AS)	M
629.3	Blue-headed Vireo	*Vireo solitarius*	(AS)	M
627.0	Warbling Vireo	*Vireo gilvus*		S
626.0	Philadelphia Vireo	*Vireo philadelphicus*	(AS)	M
624.0	Red-eyed Vireo	*Vireo olivaceus*		S
Family:	**Corvidae**			
484.0	Gray Jay	*Perisoreus canadensis*		R
492.0	Pinyon Jay	*Gymnorhinus cyanocephalus*		R
478.0	Steller's Jay	*Cyanocitta stelleri*		R
477.0	Blue Jay	*Cyanocitta cristata*		R
481.0	Western Scrub-Jay	*Aphelocoma californica*	(FL)	R, NSS3/II
491.0	Clark's Nutcracker	*Nucifraga columbiana*		R
475.0	Black-billed Magpie	*Pica hudsonia*		R
488.0	American Crow	*Corvus brachyrhynchos*		R
486.0	Common Raven	*Corvus corax*		R
Family:	**Alaudidae**			
474.0	Horned Lark	*Eremophila alpestris*		R
Family:	**Hirundinidae**			
611.0	Purple Martin	*Progne subis*	(AS)	S
614.0	Tree Swallow	*Tachycineta bicolor*		S
615.0	Violet-green Swallow	*Tachycineta thalassina*		S
617.0	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*		S
616.0	Bank Swallow	*Riparia riparia*		S
612.0	Cliff Swallow	*Petrochelidon pyrrhonota*		S
613.0	Barn Swallow	*Hirundo rustica*		S
Family:	**Paridae**			
735.0	Black-capped Chickadee	*Poecile atricapillus*		R
738.0	Mountain Chickadee	*Poecile gambeli*		R
733.0	Juniper Titmouse	*Baeolophus ridgwayi*	(FL)	R, NSS3/II
Family:	**Aegithalidae**			
743.0	Bushtit	*Psaltriparus minimus*	(FL)	S, NSS3/II
Family:	**Sittidae**			
728.0	Red-breasted Nuthatch	*Sitta canadensis*		R
727.0	White-breasted Nuthatch	*Sitta carolinensis*		R
730.0	Pygmy Nuthatch	*Sitta pygmaea*		R, NSSU/II
Family:	**Certhiidae**			
726.0	Brown Creeper	*Certhia americana*		R
Family:	**Troglodytidae**			
715.0	Rock Wren	*Salpinctes obsoletus*		S
717.0	Canyon Wren	*Catherpes mexicanus*		R
721.0	House Wren	*Troglodytes aedon*		S
722.1	Pacific Wren	*Troglodytes pacificus*	(AS)	M
722.0	Winter Wren	*Troglodytes troglodytes*	(AS)	M
724.0	Sedge Wren	*Cistothorus platensis*	(AS)	A
725.0	Marsh Wren	*Cistothorus palustris*		S
718.0	Carolina Wren	*Thryothorus ludovicianus*	(AS)	A
719.0	Bewick's Wren	*Thryomanes bewickii*	(FL)	S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Family: Polioptilidae				
751.0	Blue-gray Gnatcatcher	*Polioptila caerulea*		S
Family: Cinclidae				
701.0	American Dipper	*Cinclus mexicanus*		R
Family: Regulidae				
748.0	Golden-crowned Kinglet	*Regulus satrapa*		R
749.0	Ruby-crowned Kinglet	*Regulus calendula*		S
Family: Turdidae				
766.0	Eastern Bluebird	*Sialia sialis*	(FL)	S
767.0	Western Bluebird	*Sialia mexicana*	(AS)	S
768.0	Mountain Bluebird	*Sialia currucoides*		S
754.0	Townsend's Solitaire	*Myadestes townsendi*		R
756.0	Veery	*Catharus fuscescens*		S
757.0	Gray-cheeked Thrush	*Catharus minimus*	(AS)	M
758.0	Swainson's Thrush	*Catharus ustulatus*		S
759.0	Hermit Thrush	*Catharus guttatus*		S
755.0	Wood Thrush	*Hylocichla mustelina*	(AS)	M
761.0	American Robin	*Turdus migratorius*		R
763.0	Varied Thrush	*Ixoreus naevius*	(AS)	M
Family: Mimidae				
704.0	Gray Catbird	*Dumetella carolinensis*		S
705.0	Brown Thrasher	*Toxostoma rufum*		S
702.0	Sage Thrasher	*Oreoscoptes montanus*		S, NSS4/II
703.0	Northern Mockingbird	*Mimus polyglottos*		S
Family: Sturnidae				
493.0	European Starling	*Sturnus vulgaris*		R
Family: Motacillidae				
697.0	American Pipit	*Anthus rubescens*		S
700.0	Sprague's Pipit	*Anthus spragueii*	(AS)	M
Family: Bombycillidae				
618.0	Bohemian Waxwing	*Bombycilla garrulus*		W
619.0	Cedar Waxwing	*Bombycilla cedrorum*		R
Family: Calcariidae				
536.0	Lapland Longspur	*Calcarius lapponicus*		W
538.0	Chestnut-collared Longspur	*Calcarius ornatus*	(FL)	S, NSS4/II
537.0	Smith's Longspur	*Calcarius pictus*	(AS)	A
539.0	McCown's Longspur	*Rhynchophanes mccownii*		S, NSS4/II
534.0	Snow Bunting	*Plectrophenax nivalis*		W
Family: Parulidae				
674.0	Ovenbird	*Seiurus aurocapilla*		S
639.0	Worm-eating Warbler	*Helmitheros vermivorum*	(AS)	A
675.0	Northern Waterthrush	*Seiurus noveboracensis*		M
642.0	Golden-winged Warbler	*Vermivora chrysoptera*	(AS)	A
641.0	Blue-winged Warbler	*Vermivora cyanoptera*	(AS)	A
636.0	Black-and-white Warbler	*Mniotilta varia*	(FL)	M
637.0	Prothonotary Warbler	*Protonotaria citrea*	(AS)	A
647.0	Tennessee Warbler	*Oreothlypis peregrina*	(FL)	M
646.0	Orange-crowned Warbler	*Oreothlypis celata*		S
645.0	Nashville Warbler	*Oreothlypis ruficapilla*	(FL)	M

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
644.0	Virginia's Warbler	*Oreothlypis virginiae*	(FL)	S
678.0	Connecticut Warbler	*Oporornis agilis*	(AS)	A
680.0	MacGillivray's Warbler	*Geothlypis tolmiei*		S
679.0	Mourning Warbler	*Geothlypis philadelphia*	(AS)	A
677.0	Kentucky Warbler	*Geothlypis formosus*	(AS)	A
681.0	Common Yellowthroat	*Geothlypis trichas*		S
684.0	Hooded Warbler	*Setophaga citrina*	(AS)	A
687.0	American Redstart	*Setophaga ruticilla*		S
650.0	Cape May Warbler	*Setophaga tigrina*	(AS)	A
648.0	Northern Parula	*Setophaga americana*	(FL)	M
657.0	Magnolia Warbler	*Setophaga magnolia*	(FL)	M
660.0	Bay-breasted Warbler	*Setophaga castanea*	(AS)	M
662.0	Blackburnian Warbler	*Setophaga fusca*	(AS)	M
652.0	Yellow Warbler	*Dendroica petechia*		S
659.0	Chestnut-sided Warbler	*Setophaga pensylvanica*	(FL)	M
661.0	Blackpoll Warbler	*Setophaga striata*	(FL)	M
654.0	Black-throated Blue Warbler	*Setophaga caerulescens*	(FL)	M
672.0	Palm Warbler	*Setophaga palmarum*	(AS)	M
671.0	Pine Warbler	*Setophaga pinus*	(AS)	A
655.0	Yellow-rumped Warbler	*Setophaga coronata*		S
663.0	Yellow-throated Warbler	*Setophaga dominica*	(AS)	A
673.0	Prairie Warbler	*Setophaga discolor*	(AS)	A
665.0	Black-throated Gray Warbler	*Setophaga nigrescens*	(FL)	S
668.0	Townsend's Warbler	*Setophaga townsendi*		S
669.0	Hermit Warbler	*Setophaga occidentalis*	(AS)	A
667.0	Black-throated Green Warbler	*Setophaga virens*	(AS)	A
686.0	Canada Warbler	*Cardellina canadensis*	(AS)	A
685.0	Wilson's Warbler	*Cardellina pusilla*		S
690.0	Red-faced Warbler	*Cardellina rubrifrons*	(AS)	A
683.0	Yellow-breasted Chat	*Icteria virens*		S
Family:	**Emberizidae**			
590.0	Green-tailed Towhee	*Pipilo chlorurus*		S
587.0	Spotted Towhee	*Pipilo maculatus*		S
591.0	Canyon Towhee	*Pipilo fusca*	(AS)	A
578.0	Cassin's Sparrow	*Peucaea cassinii*	(AS)	A, (AS) except confirmed breeding in Torrington area
559.0	American Tree Sparrow	*Spizelloides arborea*		W
560.0	Chipping Sparrow	*Spizella passerina*		S
561.0	Clay-colored Sparrow	*Spizella pallida*		S
562.0	Brewer's Sparrow	*Spizella breweri*		S, NSS4/II
563.0	Field Sparrow	*Spizella pusilla*	(AS)	S
540.0	Vesper Sparrow	*Pooecetes gramineus*		S
552.0	Lark Sparrow	*Chondestes grammacus*		S
573.0	Black-throated Sparrow	*Amphispiza bilineata*	(AS)	S
574.3	Sagebrush Sparrow	*Artemisiospiza nevadensis*		S, NSS4/II
605.0	Lark Bunting	*Calamospiza melanocorys*		S
542.0	Savannah Sparrow	*Passerculus sandwichensis*		S
546.0	Grasshopper Sparrow	*Ammodramus savannarum*		S, NSS4/II
545.0	Baird's Sparrow	*Ammodramus bairdii*	(AS)	S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
548.0	Le Conte's Sparrow	*Ammodramus leconteii*	(AS)	M
549.1	Nelson's Sparrow	*Ammodramus nelsoni*	(AS)	A
585.0	Fox Sparrow	*Passerella iliaca*		R
581.0	Song Sparrow	*Melospiza melodia*		R
583.0	Lincoln's Sparrow	*Melospiza lincolnii*		S
584.0	Swamp Sparrow	*Melospiza georgiana*	(FL)	M
558.0	White-throated Sparrow	*Zonotrichia albicollis*		M
553.0	Harris's Sparrow	*Zonotrichia querula*		W
554.0	White-crowned Sparrow	*Zonotrichia leucophrys*		S
557.0	Golden-crowned Sparrow	*Zonotrichia atricapilla*	(AS)	A
567.7	Dark-eyed Junco	*Junco hyemalis*		R, Includes White-winged (566.0), Slate-colored (567.0), Oregon (567.1), Pink-sided (568.0), and Gray-headed (569.0)
Family: Cardinalidae				
609.0	Hepatic Tanager	*Piranga flava*	(AS)	A
610.0	Summer Tanager	*Piranga rubra*	(FL)	M
608.0	Scarlet Tanager	*Piranga olivacea*	(AS)	A
607.0	Western Tanager	*Piranga ludoviciana*		S
593.0	Northern Cardinal	*Cardinalis cardinalis*	(AS)	M
594.1	Yellow Grosbeak	*Pheucticus chrysopeplus*	(AS)	A
595.0	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	(FL)	S
596.0	Black-headed Grosbeak	*Pheucticus melanocephalus*		S
597.0	Blue Grosbeak	*Passerina caerulea*		S
599.0	Lazuli Bunting	*Passerina amoena*		S
598.0	Indigo Bunting	*Passerina cyanea*	(FL)	S
601.0	Painted Bunting	*Passerina ciris*	(AS)	A
604.0	Dickcissel	*Spiza americana*	(FL)	S, NSS4/II
Family: Icteridae				
494.0	Bobolink	*Dolichonyx oryzivorus*	(FL)	S, NSS4/II
498.0	Red-winged Blackbird	*Agelaius phoeniceus*		S
501.0	Eastern Meadowlark	*Sturnella magna*	(AS)	A
501.1	Western Meadowlark	*Sturnella neglecta*		S
497.0	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*		S
509.0	Rusty Blackbird	*Euphagus carolinus*	(AS)	M
510.0	Brewer's Blackbird	*Euphagus cyanocephalus*		S
511.0	Common Grackle	*Quiscalus quiscula*		S
512.0	Great-tailed Grackle	*Quiscalus mexicanus*	(FL)	A
495.0	Brown-headed Cowbird	*Molothrus ater*		S
506.0	Orchard Oriole	*Icterus spurius*	(FL)	S
508.0	Bullock's Oriole	*Icterus bullockii*		S
507.0	Baltimore Oriole	*Icterus galbula*	(AS)	A
504.0	Scott's Oriole	*Icterus parisorum*	(AS)	S
Family: Fringillidae				
514.1	Brambling	*Fringilla montifringilla*	(AS)	A
524.0	Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*		R
525.0	Black Rosy-Finch	*Leucosticte atrata*		R, NSSU/II
526.0	Brown-capped Rosy-Finch	*Leucosticte australis*	(FL)	R, NSSU/II

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
515.0	Pine Grosbeak	*Pinicola enucleator*		R
519.0	House Finch	*Haemorhous mexicanus*		R
517.0	Purple Finch	*Haemorhous purpureus*	(AS)	W
518.0	Cassin's Finch	*Haemorhous cassini*		R
521.0	Red Crossbill	*Loxia curvirostra*		R
522.0	White-winged Crossbill	*Loxia leucoptera*	(FL)	R
528.0	Common Redpoll	*Acanthis flammea*		W
527.0	Hoary Redpoll	*Acanthis hornemanni*	(AS)	W
533.0	Pine Siskin	*Spinus pinus*		R
530.0	Lesser Goldfinch	*Spinus psaltria*	(FL)	M
531.0	Lawrence's Goldfinch	*Spinus lawrencei*	(AS)	A
529.0	American Goldfinch	*Spinus tristis*		R
514.0	Evening Grosbeak	*Coccothraustes vespertinus*		R
Family: Passeridae				
688.2	House Sparrow	*Passer domesticus*		R
Note: the following avian species have been documented in Wyoming, but these are human-assisted species and, as such, are not recognized as wild, naturally occurring species in the state. <u>**Controlled Species**</u> <u>**Waterfowl**</u> **Order: Anseriformes** **Family: Anatidae**				
178.0	Fulvous Whistling-Duck	*Dendrocygna bicolor*	(AS)	A, Controlled
178.2	Mute Swan	*Cygnus olor*	(AS)	A, Controlled
141.2	Ruddy Shelduck	*Tadorna ferruginea*		A, Controlled
141.1	Common Shelduck	*Tadorna tadorna*		A, Controlled
Pigeons and Doves **Order: Columbiformes** **Family: Columbidae**				
315.2	African Collared-Dove	*Streptopelia roseogrisea*		A, Controlled
Passerines **Order: Passeriformes** **Family: Fringillidae**				
526.1	European Goldfinch	*Carduelis carduelis*		A, Controlled
***MAMMALS* [d, e]**				
<u>**Marsupials**</u> **Order: Didelphimorphia** **Family: Didelphidae**				
800.0	Virginia Opossum	*Didelphis virginiana*		A
<u>**Insectivores**</u> **Order: Soricomorpha** **Family: Soricidae**				
801.0	Masked Shrew	*Sorex cinereus*		R
801.1	Hayden's Shrew	*Sorex haydeni*		R
806.0	American Pygmy Shrew	*Sorex hoyi*		R, NSS2/II
805.0	Merriam's Shrew	*Sorex merriami*		R
807.0	Dusky Shrew	*Sorex monticolus*		R
803.0	Dwarf Shrew	*Sorex nanus*		R, NSS3/II
804.0	Western Water Shrew	*Sorex navigator*		R
804.1	Preble's Shrew	*Sorex preblei*		R, NSS3/III
802.0	Vagrant Shrew	*Sorex vagrans*		R

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information a, b
Family: Talpidae				
810.0	Eastern Mole	*Scalopus aquaticus*		R
Bats **Order: Chiroptera** **Family: Vespertilionidae**				
815.1	California Myotis	*Myotis californicus*		U
816.0	Western Small-footed Myotis	*Myotis ciliolabrum*		U, NSS4/II
818.0	Long-eared Myotis	*Myotis evotis*		U, NSS3/II
819.0	Northern Long-eared Myotis	*Myotis septentrionalis*		U, NSS3/II
815.0	Little Brown Myotis	*Myotis lucifugus*		U, NSS4/II
826.0	Fringed Myotis	*Myotis thysanodes*		U, NSS3/II
817.0	Long-legged Myotis	*Myotis volans*		U, NSS3/II
817.1	Yuma Myotis	*Myotis yumanensis*		U
821.0	Eastern Red Bat	*Lasiurus borealis*		S, NSSU/II
822.0	Hoary Bat	*Lasiurus cinereus*		S
820.0	Silver-haired Bat	*Lasionycteris noctivagans*		U
820.1	American Perimyotis	*Perimyotis subflavus*		U
825.0	Big Brown Bat	*Eptesicus fuscus*		U
824.0	Spotted Bat	*Euderma maculatum*		S, NSS3/II
823.0	Townsend's Big-eared Bat	*Corynorhinus townsendii*		U, NSS2/I
827.0	Pallid Bat	*Antrozous pallidus*		S, NSS3/III
Family: Molossidae				
828.0	Brazilian Free-tailed Bat	*Tadarida brasiliensis*		A
829.0	Big Free-tailed Bat	*Nyctinomops macrotis*		A
Lagomorphs **Order: Lagomorpha** **Family: Ochotonidae**				
830.0	American Pika	*Ochotona princeps*		R, NSSU/II
Family: Leporidae				
837.0	Pygmy Rabbit	*Brachylagus idahoensis*		R, NSS3/II
833.0	Desert Cottontail *	*Sylvilagus audubonii*		R
834.0	Eastern Cottontail *	*Sylvilagus floridanus*		R
835.0	Mountain Cottontail *	*Sylvilagus nuttallii*		R
836.0	Snowshoe Hare *	*Lepus americanus*		R
832.0	Black-tailed Jackrabbit *	*Lepus californicus*		R, Predatory animal
831.0	White-tailed Jackrabbit *	*Lepus townsendii*		R, Predatory animal
Rodents **Order: Rodentia** **Family: Sciuridae**				
841.0	Yellow-pine Chipmunk	*Tamias amoenus*		R, NSS4/III
842.0	Cliff Chipmunk	*Tamias dorsalis*		R, NSS3/II
840.0	Least Chipmunk	*Tamias minimus*		R
843.0	Uinta Chipmunk	*Tamias umbrinus*		R, NSS4/III
844.0	Yellow-bellied Marmot	*Marmota flaviventris*		R
846.0	Uinta Ground Squirrel	*Urocitellus armatus*		R
845.0	Wyoming Ground Squirrel	*Urocitellus elegans*		R
849.0	Golden-mantled Ground Squirrel	*Callospermophilus lateralis*		R
847.0	Spotted Ground Squirrel	*Xerospermophilus spilosoma*		R, NSS4/III
848.0	Thirteen-lined Ground Squirrel	*Ictidomys tridecemlineatus*		R
851.0	White-tailed Prairie Dog	*Cynomys leucurus*		R

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
850.0	Black-tailed Prairie Dog	*Cynomys ludovicianus*		R
855.0	Abert's Squirrel	*Sciurus aberti*		R
856.0	Eastern Gray Squirrel *	*Sciurus carolinensis*		R
852.0	Eastern Fox Squirrel *	*Sciurus niger*		R
854.0	Red Squirrel *	*Tamiasciurus hudsonicus*		R
853.0	Northern Flying Squirrel	*Glaucomys sabrinus*		R, NSS4/II
Family: Geomyidae				
862.0	Wyoming Pocket Gopher	*Thomomys clusius*		R, NSS3/II
863.0	Idaho Pocket Gopher	*Thomomys idahoensis*		R, NSS3/II
860.0	Northern Pocket Gopher	*Thomomys talpoides*		R
861.0	Sand Hills Pocket Gopher	*Geomys lutescens*		R, NSS4/II
Family: Heteromyidae				
865.0	Olive-backed Pocket Mouse	*Perognathus fasciatus*		R, NSS4/II
893.0	Plains Pocket Mouse	*Perognathus flavescens*		R, NSS4/II
866.0	Silky Pocket Mouse	*Perognathus flavus*		R, NSS3/II
867.0	Great Basin Pocket Mouse	*Perognathus mollipilosus*		R, NSS3/II
868.0	Hispid Pocket Mouse	*Chaetodipus hispidus*		R, NSS3/II
869.0	Ord's Kanagroo Rat	*Dipodomys ordii*		R
Family: Castoridae				
875.0	Beaver *	*Castor canadensis*		R
Family: Muridae				
877.0	Western Harvest Mouse	*Reithrodontomys megalotis*		R
876.0	Plains Harvest Mouse	*Reithrodontomys montanus*		R, NSS3/II
878.0	Canyon Deermouse	*Peromyscus crinitus*		R, NSS3/II
881.0	White-footed Deermouse	*Peromyscus leucopus*		R
880.0	North American Deermouse	*Peromyscus maniculatus*		R
879.0	Piñon Deermouse	*Peromyscus truei*		R, NSS3/II
882.0	Northern Grasshopper Mouse	*Onychomys leucogaster*		R
883.0	Bushy-tailed Woodrat	*Neotoma cinerea*		R
884.0	Southern Red-backed Vole	*Myodes gapperi*		R
885.0	Western Heather Vole	*Phenacomys intermedius*		R
888.0	Long-tailed Vole	*Microtus longicaudus*		R
887.0	Montane Vole	*Microtus montanus*		R
890.0	Prairie Vole	*Microtus ochrogaster*		R
886.0	Meadow Vole	*Microtus pennsylvanicus*		R
889.0	Water Vole	*Microtus richardsoni*		R, NSS3/II
891.0	Sagebrush Vole	*Lemmiscus curtatus*		R
892.0	Common Muskrat *	*Ondatra zibethicus*		R
894.2	Norway Rat	*Rattus norvegicus*		R
894.1	House Mouse	*Mus musculus*		R
Family: Didopidae				
895.0	Meadow Jumping Mouse	*Zapus hudsonius*		R
895.1	Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*		R, NSS4/II
896.0	Western Jumping Mouse	*Zapus princeps*		R
Family: Erethizontidae				
900.0	North American Porcupine *	*Erethizon dorsatum*		R, Predatory animal
Carnivores **Order: Carnivora** **Family: Canidae**				
901.0	Coyote *	*Canis latrans*		R, Predatory animal

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
902.0	Gray Wolf *	*Canis lupus*		R
904.0	Swift Fox	*Vulpes velox*		R, NSS4/II
903.0	Red Fox *	*Vulpes vulpes*		R, Predatory animal
905.0	Common Gray Fox	*Urocyon cinereoargenteus*		R
Family: Ursidae				
940.0	Black Bear *	*Ursus americanus*		R
941.0	Grizzly Bear *	*Ursus arctos*		R, Threatened
Family: Procyonidae				
906.0	Ringtail	*Bassariscus astutus*		R
907.0	Northern Raccoon *	*Procyon lotor*		R, Predatory animal
Family: Mustelidae				
908.0	Pacific Marten *	*Martes caurina*		R
909.0	Fisher	*Pekania pennanti*		R
910.0	Short-tailed Weasel (Ermine) *	*Mustela erminea*		R
911.0	Long-tailed Weasel *	*Mustela frenata*		R
913.0	Black-footed Ferret	*Mustela nigripes*		R, Endangered, NSS1/I
919.0	Least Weasel	*Mustela nivalis*		R, NSSU/III
912.0	American Mink *	*Vison vison*		R
914.0	Wolverine	*Gulo gulo*		R, NSS3/II
915.0	American Badger *	*Taxidea taxus*		R
916.1	Western Spotted Skunk *	*Spilogale gracilis*		R, Predatory animal
916.0	Eastern Spotted Skunk *	*Spilogale putorius*		R, Predatory animal
917.0	Striped Skunk *	*Mephitis mephitis*		R, Predatory animal
918.0	Northern River Otter	*Lontra canadensis*		R, NSSU/II
Family: Felidae				
922.0	Mountain Lion (Puma) *	*Puma concolor*		R
920.0	Canada Lynx	*Lynx canadensis*		R, Threatened, NSS1/I
921.0	Bobcat *	*Lynx rufus*		R
Ungulates **Order: Artiodactyla** **Family: Cervidae**				
930.0	Wapiti (Elk) *	*Cervus canadensis*		R
932.0	Mule Deer (Black-tailed Deer) *	*Odocoileus hemionus*		R
933.0	White-tailed Deer *	*Odocoileus virginianus*		R
931.0	Moose *	*Alces americanus*		R, NSS4/II
Family: Antilocapridae				
935.0	Pronghorn *	*Antilocapra americana*		R
Family: Bovidae				
925.0	Bison *	*Bos bison*		R
926.0	Mountain Goat *	*Oreamnos americanus*		R
927.0	Bighorn Sheep (Mountain Sheep) *	*Ovis canadensis*		R, NSS4/II
		AMPHIBIANS [f]		
Salamanders **Order: Caudata** **Family: Ambystomatidae**				
950.0	Tiger Salamander	*Ambystoma mavortium*		R; includes Blotched, Western (NSS4/III), and Arizona subspecies

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Toads and Frogs **Order: Anura** **Family: Pelobatidae**				
951.0	Plains Spadefoot	*Spea bombifrons*		R, NSSU/III
951.1	Great Basin Spadefoot	*Spea intermontana*		R, NSSU/I
Family: Bufonidae				
951.2	Western Toad	*Anaxyrus boreas*		R, NSS1/I
951.3	Great Plains Toad	*Anaxyrus cognatus*		R, NSSU/III
951.5	Wyoming Toad	*Anaxyrus baxteri*		R, NSS1/I
951.4	Rocky Mountain Toad (Woodhouse's Toad)	*Anaxyrus woodhousii woodhousii*		R
Family: Ranidae				
952.1	American Bullfrog	*Lithobates catesbeianus*		R
952.2	Northern Leopard Frog	*Lithobates pipiens*		R, NSSU/III
952.3	Columbia Spotted Frog	*Rana luteiventris*		R, NSS3/II
952.4	Wood Frog	*Lithobates sylvaticus*		R, NSS2/II
Family: Hylidae				
952.0	Boreal Chorus Frog	*Pseudacris maculata*		R
REPTILES [f]				
Turtles **Order: Testudines** **Family: Trionychidae**				
953.0	Eastern Spiny Softshell	*Apalone spinifera spinifera*		R, NSS4/III
Family: Testudinidae				
953.2	Plains Box Turtle	*Terrapene ornata ornata*		R, NSSU/III
953.3	Western Painted Turtle	*Chrysemys picta bellii*		R, NSS4/III
Family: Chelydridae				
953.1	Snapping Turtle	*Chelydra serpentina*		R
Lizards **Order: Squamata** **Family: Teiidae**				
954.0	Prairie Racerunner	*Aspidoscelis sexlineata viridis*		R, NSSU/II
Family: Scincidae				
954.1	Northern Many-lined Skink	*Plestidon multivirgatus multivirgatus*		R, NSSU/III
954.9	Great Basin Skink	*Plestiodon skiltonianus utahensis*		R, NSSU/III
Family: Iguanidae				
954.3	Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*		R
954.4	Plateau Fence Lizard	*Sceloporus tristichus*		R
954.6	Prairie Lizard	*Sceloporus consobrinus*		R, NSSU/II
954.8	Northern Tree Lizard	*Urosaurus ornatus wrighti*		R, NSS1/II
954.2	Greater Short-horned Lizard	*Phrynosoma hernandesi*		R, NSS4/III
954.7	Great Plains Earless Lizard	*Holbrookia maculata maculata*		R, NSSU/III
Snakes **Order: Squamata** **Family: Boidae**				
955.2	Northern Rubber Boa	*Charina bottae*		R, NSS3/II
Family: Colubridae				
955.3	Plains Hog-nosed Snake	*Heterodon nasicus*		R, NSSU/II
956.2	Eastern Yellow-bellied Racer	*Coluber constrictor flaviventris*		R
956.6	Desert Striped Whipsnake	*Coluber taeniatus taeniatus*		R

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
956.3	Smooth Greensnake	*Opheodrys vernalis*		R, NSS3/II
955.4	Black Hills Red-bellied Snake	*Storeria occipitomaculata pahasapae*		R, NSSU/II
956.1	Pale Milksnake	*Lampropeltis triangulum multistriata*		R, NSS3/II
955.6	Great Basin Gophersnake	*Pituophis catenifer deserticola*		R, NSS2/II
955.5	Bullsnake	*Pituophis catenifer sayi*		R
956.4	Plains Black-headed Snake	*Tantilla nigriceps*		R, NSSU/II
955.8	Wandering Gartersnake	*Thamnophis elegans vagrans*		R
956.0	Valley Gartersnake	*Thamnophis sirtalis fitchi*		R, NSSU/II
955.9	Red-sided Gartersnake	*Thamnophis sirtalis parietalis*		R, NSSU/II
955.7	Plains Gartersnake	*Thamnophis radix*		R, NSSU/II
Family:	**Crotalidae**			
955.0	Prairie Rattlesnake	*Crotalus viridis*		R
955.1	Midget Faded Rattlesnake	*Crotalus oreganus concolor*		R, NSS1/I

[a] Species seasonal status: R = year-round resident, S = summer resident, W = winter resident, M = migrant, A = accidental occurrence in Wyoming, U = residency status in Wyoming is unknown.

[b] Wyoming Game and Fish Department Species of Greatest Conservation Need with a Native Species Status (NSS) of 1, 2, 3, 4, or unknown and Conservation Tier I, II, or III (WGFD 2010) .

[c] Common and scientific names and species order are from the American Ornithologists' Union (1983, 2015). An "(AS)" indicates species for which full written documentation of all sightings is requested by the Wyoming Bird Records Committee; an "(FL)" indicates species for which documentation is only requested for the first sighting in each latilong and all nesting observations. In addition, full documentation is required for any species not listed here and for observations of breeding attempts.

[d] An asterisk following a species common name indicates those species classified as game, predacious bird, predatory animal, or furbearer by state statute or Wyoming Game and Fish Commission Regulation.

[e] Common and scientific names and species order are from Bradley et al. (2014).

[f] Common and scientific names and species order are from Baxter and Stone (1992) and Crother (2012).

LITERATURE CITED

American Ornithologists' Union. 1983. Check-list of North American birds, seventh edition. Allen Press, Inc., Lawrence, Kansas, USA.

American Ornithologists' Union. 2015. Fifty-sixth supplement to the American Ornithologists' Union check-list of North American birds. Auk 132(3):748-764.

Bradley, R. D., L. K. Ammerman, R. J. Baker, L. C. Bradley, J. A. Cook, R. C. Dowler, C. Jones, D. J. Schmidly, F. B. Stangl, Jr., R. A. Van Den Bussche, and B. Würsig. 2014. Revised checklist of North American mammals north of Mexico, 2014. Occasional Papers, Museum of Texas Technical University, Number 327, Lubbock, USA.

Baxter, G. T., and M. D. Stone. 1992. Amphibians and reptiles of Wyoming. Wyoming Game and Fish Department, Cheyenne, USA.

Crother, B.I. (Editor). 2012. Scientific and standard English names of amphibians and reptiles of North American North of Mexico, with comments regarding confidence in our understanding, seventh edition. Society for the Study of Amphibians and Reptiles Herpetological Circular 39:1-92.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.